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"AN INVESTIGATION INTO COMMUNICATION STUDIES TO IMPROVE THE DESIGNER'S UNDERSTANDING OF THE VIRTUES AND CONSTRAINTS OF THE THREE DIMENSIONAL GRAPHICAL USER INTERFACE."

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"Everybody experiences far more than he understands. Yet it is experience, rather than understanding, that influences behaviour." Marshall McLuhan.[1]

[1] McLuhan, M. In: Brand, S. *The Media Lab: Inventing the future at M.I.T.* Penguin, 1989.

ABSTRACT

This research set out to understand the role of design in Virtual Reality (VR) interfaces.

The hypothesis was that:
Virtual Reality is an emerging medium and does not currently fulfil its full design potential as a medium for communication.

Existing research and practice in VR is dominated by Human-Computer Interface (HCI) developers and typically lacks a design approach. The result of this is that many VR projects are developed to mirror reality (mimesis) without considering the potential for the medium to portray ideas in novel or user-led ways. Many designers working in this field take an empirical approach without reference to guidelines or theory, relying on previous experience with other media.

The proposition of this research was that there may be more value in a theoretical and holistic approach that combines knowledge from different disciplines to reveal new insights. The research therefore used a qualitative approach to understand the contribution designers, and the design process, could make to this subject.

Information was gathered through a two stage series of case studies and semi-structured expert interviews. This research documented in detail a design approach to the development of VR undertaken at BT and in design consultancy. In particular, the investigation looked at the design characteristics of state-of-the-art Virtual Reality projects, highlighting the different attributes (virtues and constraints) of the Virtual Reality medium. These virtues were found to be: interactive, fun and intuitive, illustrates relationships, spatial arrangement of data, navigation and landmarks, use of scale, multiple viewpoints and visualisation of complex information. The constraints were found particularly to affect representational issues (choice of sign) and technological determinism. Although technological determinism was not found to play a significant role, it did impact on the presentation of ideas due to inconsistent interfaces and poorly designed VR software tools. However, the research concluded that, until sufficient examples of practice broaden the subject matter, the generalisation of virtues and constraints of VR offers limited insight beyond the immediate context.

In order to improve the practice of VR design, a strategic approach was felt to be necessary to align VR projects to users' communication needs. The primary output of this research has been the mapping of the relationship between the more widely employed iconic (mimetic) interface and the symbolic (abstract) interface in relation to different dimensionality (2D/3D/VR). This matrix was formulated from issues identified in the literature review and refined through expert panels relating to communication theories. The framework demonstrates different representations, virtues and constraints, as well as the relationship between different media types. The benefit of this framework is that it links communication theory with the pragmatics of the designer, thereby integrating broader communication concepts through a visual mapping process. This integration of theory and practice was critical to testing the model with real examples, as well as to presenting the findings to design practitioners. Additionally, this matrix provides a framework to identify future design opportunities.

A further output of the research has been the development of two models to illustrate alternative approaches to the design of VR environments by understanding the process of deconstruction and construction of signs. One outcome of the case studies was the discovery that the design approach undertaken at BT allowed the development of representations which were not merely transposed to VR but rather designed for the purpose and for users. It was recommended that for the design of Virtual Environments, signs be deconstructed and transformed to enable creative solutions to be developed. This was felt to add significant benefits over transposing signs, as is typically the approach with more descriptive VR projects. The research also recommends that to reduce the impact of technological determinism, software designers make tools to build objects more easily rather than providing pre-built clip objects.

It was considered that as a result of this research designers would have a clearer understanding of their role in VR development and be better equipped to tackle the design of virtual worlds that could capitalise on the unique attributes of the medium. However, it is suggested that further case studies be mapped onto the matrix to refine it further and that the resulting model should be tested in new contexts and developed further with designers to confirm the value of the findings.

THE USE OF THREE DIMENSIONAL IMAGES IN GRAPHICAL USER INTERFACE

A summary of relevant publications, papers and conference presentations from the research project:

COOPER, A. & SIODMOK, P.	2002	*"The Use of Solids / Surface Modelling and Virtual Reality in Industrial Design"* Tools and Methods of Competitive Engineering, Wuhan Hubey, China.
COOPER, A.	2001	*"Beyond the Icon"* Digital Creativity, Vol. 12, Number 2, 2001.
COOPER, A.	2000	*"The Role of Three Dimensions and VR in Graphical User Interface Design"* Design in Business Week, 'Digital Media Design', Design Works, Gateshead, UK.
COOPER, A. & SIODMOK, P.	2000	*"The Use of Alias in Industrial Design and the Benefits of an Integrated Solids / Surfacing Methodology"* 3rd International Symposium on Industrial Design, Hong Kong Productivity Council (HKPC), Hong Kong.
COOPER, A.	1998	*"Can Three Dimensionality Reveal New Knowledge?"* 'Multi-viewpoint: Shaping the Human Computer Interface', Design Research Society, Centre for Design Research, University of Northumbria.
COOPER, A.	1998	Organiser *"Visualising the Future"* Forum - Ipswich BT Labs in Collaboration with University of Northumbria at Newcastle.
COOPER, A.	1998	Computers in Art and Design Education Post-graduate Forum, Sheffield Hallam University.
COOPER, A.	1997	Computers in Art and Design Education Post-graduate Forum, Glasgow School of Art.
COOPER, A.	1996	*"Visualising the Future"* Semiotics, Semantics and Design. Centre for Design Research, University of Northumbria at Newcastle.

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ABBREVIATIONS

AAAD	-	Action at a Distance
AI	-	Artificial Intelligence
AR	-	Augmented Reality
AV	-	Augmented Virtuality
BT	-	British Telecom
CAD	-	Computer Aided Design
CAID	-	Computer Aided Industrial Design
CAVE	-	Cave Automatic Virtual Environment
CAPE	-	Computer Aided Production Engineering
CGI	-	Computer Graphics Imaging
CSCW	-	Computer Supported Collaborative Work
CVE	-	Collaborative Virtual Environment
DOS	-	Disc Operating System
DOF	-	Degrees of Freedom (as in 6 DOF e.g. space mouse)
DRS	-	Design Research Society
EMCON	-	Emotional Icon
GUI	-	Graphical User Interface
HCI	-	Human-Computer Interaction
HITL	-	Human Interface Technology Lab
HTML	-	Hyper Text Mark-up Language
HMD	-	Head Mounted Display
IBR	-	Image Based Rendering
IA	-	Intelligent Agent
IT	-	Information Technology
IV	-	Information Visualisation
K=P	-	Knowledge = Power
LOD	-	Level of Detail
MOO	-	Multi-User Domains Object Orientated
MR	-	Mixed Reality
MUD	-	Multi User Domain
NASA	-	National Aeronautics and Space Administration
NCSA	-	National Center for Supercomputing Applications

NT	-	Network Technology
OS	-	Operating System
PARC	-	Palo Alto Research Center
PC	-	Personal Computer
QTVR	-	Quick Time Virtual Reality
RV	-	Reality -Virtuality
SGI	-	Silicon Graphics Iris
SOC	-	Simulation of Complexity
SOR	-	Simulation of Reality
TBC	-	Text Based Communication
UI	-	User Interface
VE	-	Virtual Environment
VR	-	Virtual Reality
VRML	-	Virtual Reality Modelling Language
WIMP	-	Windows, Icons, Menus, Pointer
WYSIWYG	-	What You See Is What You Get

CHAPTER 1.0: INTRODUCTION

The research involved an investigation, using semiotics and communication theory, to look at the design of signs and representation in VR. The goal of the research was to identify the underpinning philosophical and representational design issues and subsequently reveal, through examples of practice, the unique virtues and constraints of the medium. The strength of this approach lies in the combination of theory and practice from a designer's perspective to provide new insight into the medium's potential capabilities.

1.1 Background to the Research Project

The development of communication has created a different consideration of the world at different times. In the broadest sense, the methods we use to communicate define reality at both an experiential and cultural level. Although the world may appear as a universal sensory experience (reality), most philosophers would view this as simplistic, based on common sense rather than an approach which considers the complex interplay of a multitude of other factors. Such factors, which are the focus of semiotics, include the audience's experience, the context, the medium which carries the message, and the construction of the message from individual signs. The study of semiotics is preoccupied with the task of identifying the relationships involved in communication in the broadest sense and in this way it looks at how people communicate using different systems of signs.

The basic requirement of any sign system is classification and categorisation which takes the world as an undefined mass and breaks it down to enable concepts to be defined. If the example of nomenclature is considered, this involves the division of the reality into binary opposed concepts like 'day' and 'night' or 'good' and 'bad' from what is in reality an analogue experience.[2] Such concepts (words) are signs, which represent some aspect of a perceived reality allowing particular emphasis to be made. However, words are not reality, but rather a medium of description which presents a concept.

Direct physical world experiences are augmented by signs, which re-present the concepts in a new form. As Umberto Eco observed, the sign is a lie, it is something that stands for something else. "Thus semiotics is in principle the discipline studying everything which

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[2] Lakoff, G. & Johnson, M. *Metaphors We Live By*. The University of Chicago Press, 1980, p.162.

can be used in order to lie."[3] Yet it is this ability to communicate non-literally which has enabled the evolution of culture, as Von Bertalanffy notes: "Apart from the satisfaction of biological needs man shares with animals, he lives in a universe not of things but of symbols."[4] This is extended by Moles, who suggests:

> "Our existence then becomes more and more symbolic because it is lived more and more inside an ideographic world where we prepare our actions not with the objects themselves, but with the signs that designate them."[5]

The relationship between the real world experience and the chosen sign is critical as the sign will inevitably alter the experience of the event, due to its unique form and the codes involved in its use or transmission. A paradox ensues where the sign becomes part of the experience of reality and comes to imply the original concept. The result is the hyper-real and no longer bears relation to the original, but rather is self-referential.[6] It is within this 'Structuralist' context that the research is being undertaken, understanding that the world of signs is both constructed and designed.

Such signs subsequently form a message when a sign, or collection of signs (syntagm) is transmitted between a source (producer) and a destination (receiver), hence the act of communication. However, a prerequisite for any such communication is the presence of, or the product of, a living entity.[7] As such, human communication relies on the senses to convey and detect the message. The communication of signs involves a choice, as words form part of a whole range of media which cultures use to represent ideas. Such sign messages are communicated through media such as books, paintings, photographs, telephones and multimedia experiences in television and computers. Similarly, objects such as clothing, sculptures, furnishings and products can communicate as signs to the receiver. In the act of designing and creating these artefacts designers are building complex messages which can be both read and redefined by a culture - Findelli describes this as the Semiocosm.[8]

From Johannes Guttenberg's printing press to Charles Babbage's counting machine, technological advancement has caused significant changes in the way we can communicate

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[3] Eco, U. *A Theory of Semiotics.* Indiana University Press, 1976, p.7.
[4] Von Bertalanffy, L. In: Crozier, R. *Manufactured Pleasures: Psychological Responses to Design (Studies in Design and Material Culture).* Manchester University, 1994, p.78.
[5] Moles, A. The Legibility of the World: A Project in Graphic Design. *Design Issues,* 3 (1), p.44.
[6] Baudrillard, J. *Simulations.* Semiotext(e), 1983, p.11.
[7] Sebeok, T. *An Introduction to Semiotics.* Pinter Publishers, 1994, p.6.
[8] Findeli, A. Ethics, Aesthetics, and Design. *Design Issues,* 10 (2), Summer 1994, p.55.

using media and signs. The most recent medium, the computer, has provided an exciting new means of communicating ideas, extending our existing repertoire of signs in new ways. This medium makes it possible to send and receive information in many different forms, using a range of signs from text to animation. To date this medium has predominantly employed a two dimensional system of representation using a metaphor to relate traditional office work activities, for example using icons of pages and files on a desktop. However, as technology has improved and specialist programs have developed, the question remains: how might interfaces effectively use interactive three-dimensionality to present information to the user? Virtual Environments (VEs) have been developing since Morton Heilig invented Sensorama in 1956, with most of the work focusing on directly replicating 'reality'. Even the term Virtual Reality contains this basic premise. This single assumption raises both practical and philosophical problems, such as issues of: consistency of metaphor (e.g. if you press the lift button in a virtual world should it arrive at once or do you wait?) and issues of representation and meaning (e.g. why have a chair in VR if you can't sit on it?) Collectively these can be seen as issues of effective communication.

This research has focused on theories of communication studies, psychology and semiotics as a means of 'de-mystifying' our understanding of communication using Virtual Reality. The focus of the research is on Virtual Environments, created between 1992 and 1998 - a time when much hype was being generated about the potential of Virtual Reality, with numerous books being written and television documentaries advancing its unique properties. Such developments in media have gone as far as being proclaimed by Robins as the arrival of a new visual language. [9] This hyperbole emerged from technology commentators and the promise of popular fiction, such as Gibson's *Neuromancer*,[10] and seemed to bear little resemblance to the actual practice of designing which was being undertaken in consultancies and research labs at this time. Personal observations of design practice in industrial design consultancy suggested that designers tended to develop computer interfaces on a project-by-project basis, rather than using a strategic, holistic or philosophical approach. In this sense, the development of design work was essentially on a trial and error basis without significant evidence of reference to guidelines or reflection on practice. These observations seemed to correlate with suggestions that the design profession had its roots inherently in a history of empiricism and was therefore reluctant to

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[9] Robins, K. *Into the Image: Culture and Politics in the Field of Vision*. Routledge, 1996, p.149.
[10] Gibson, W. *Neuromancer*. Voyager, 1995, p.5.

use theory to answer design problems.[11] Similar observations were evident during early project visits to the sponsoring organisation BT, which acknowledged the limitations of its approach because of its narrow empirical base. This posed the question of what information would be relevant for designers to facilitate their practice, and how it should be communicated effectively?

These observations of practice also seemed to be compounded by the novelty of the subject matter, with few precursors or examples for designers to follow. From this basis, designers tended to rely on previous experience with more traditional media to approach new-media projects, as noted by Misera.[12] This was unsurprising, as the introduction of any new technology or media is normally preconditioned by previous experience with similar media. Yet this seemed short-sighted as Marshall McLuhan suggested: "Indeed, it is only too typical that the 'content' of any medium blinds us to the characteristics of the medium."[13] This lack of a broader perspective, seemed to pose a number of problems for the profession, with designers being increasingly influenced by the capability of their computer's built-in tools, such as the widespread use of 'clip art' readymade objects in VR. In this sense, many commercial projects had been approached from a technologically determined standpoint, with the outcomes being led by the capabilities of the software and hardware of the time.

In contrast, this research aimed to focus on an approach centred on the issues of communication studies. This, it was considered, would provide a longer-term strategic framework from which the medium could be considered; to sort out the reality from the hype. Now the hype has subsided somewhat, much VR activity has been concentrated in particular industries, namely architectural simulation, automotive, medical imaging, engineering, telecoms and training. Some of the early magic has been lost, leaving a number of questions unanswered about the ultimate possibility of revealing significant new knowledge through this medium.

When creating a Virtual Environment, an interface designer has a range of signs to choose from which may enhance or interfere with a user's ability to understand, or decode, the intended meaning. This research project has looked to make these choices explicit by

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[11] Eastman, C.M. On the Analysis of Intuitive Design Processes. In: Moore, G.T. (ed.) *Emerging Methods in Environmental Design and Planning.* M.I.T. Press, 1970. pp.21-37.
[12] Misera, T. Industrial Designers, the New Craftsmen of Media? *Multiviewpoint: Shaping the Human Computer Interface.* DRS, Centre for Design Research, Newcastle, July 02, 1998. [unpublished].
[13] McLuhan, M. Understanding Media, The Extensions of Man. Routledge, 1995, p.9.

placing them in juxtaposition with other opportunities. Having established this, the output from the project has been the development of a model to translate often very theoretical information into a useful form to be applied when designing. The approach has been from a strategic communication-based context, to derive an appropriate language and terminology. Following this, an integrated model of communication was presented which aimed to categorise image and create a visual taxonomy that communicated such theory to practising designers. It maps the characteristics of different modes of representation in order to create a context for examining two-dimensional, three-dimensional, and Virtual Reality digital interfaces.

1.2 Definition of Three Dimensional Imagery

The initial description that requires clarification is the definition of the nature of three-dimensional imagery in relation to other modes of representation. Attempts to create three-dimensional images have evolved from thousand year-old cave paintings,[14] through Renaissance perspective,[15] to the modern use of real-time Virtual Reality. Superficially, there may seem little connection between the early static pictures and advanced computer-generated animations. However, the dimensionality depicted is a visual illusion. This illusion relies on the human visual system to create the impression of three dimensions using depth cues to mimic binocular vision.[16] It is important, therefore, to note that all three-dimensional images are two dimensional, even when displayed via head-mounted displays (HMDs).

There are, however, differences that are apparent across the different types of media and these characteristics are of importance to the research. Table 1 shows a breakdown of key attributes of the three dimensional images, illustrating commonalities and differences.

<table>
<tr><th></th><th>Visual Illusions</th><th>Movement</th></tr>
<tr><td>Renaissance Perspective</td><td rowspan="3">Monocular Depth Cues, Occlusion, Size Differences, Linear Perspective, Shading, Texture Gradients and Aerial Perspective.</td><td>Static</td></tr>
<tr><td>3D Animation</td><td>Pre-determined Linear Animation
Limited Interactivity</td></tr>
<tr><td>Virtual Reality</td><td>Real-time Animation Combined with Linear Animation
Interactivity</td></tr>
</table>

Table 1: Key Attributes of Three Dimensional Images.

[14] Ashcroft, J. & Odam, J. *Getting Started with 3D: A Designer's Guide to 3D Graphics and Illustration.* Peachpit Press, 1998, p.6.
[15] McLuhan, M. *Understanding Media, The Extensions of Man.* Routledge, 1995, p.162.
[16] Ashcroft, J. & Odam, J. *Getting Started with 3D: A Designer's Guide to 3D Graphics and Illustration.* Peachpit Press, 1998, p.7.

1.3 Origin of the Programme of Research

The theme of this research was originally conceived during the researcher's undergraduate B.A. (Hons.) Design for Industry course-work final project 'Sculptural Metamorphosis'.[17] This work looked at the possibility of conveying the idea of educational achievement using a designer's skills in three-dimensional form, rather than the current use of an exam certificate. This project relied on an understanding of the nature of communication through different media to assess the implications of their subsequent use in different contexts. The challenge here was to choose the most appropriate medium for conveying the intended message.

In 1992, unrelated work at BT Laboratories had experimented with the use of three-dimensional animated form in Virtual Reality Environments (VEs) to convey emotional meaning.[18] BT's experimental trials resulted in an interface that was felt to communicate with the computer users more intuitively.[19] However, at this time the use of three dimensional imagery in Virtual Reality was a relatively new technological development, therefore its virtues and constraints were, for the most part, still to be recognised and demonstrated. This left significant questions unanswered regarding its potential application and value.

A meeting in September 1995 resulted in a proposal for collaboration with BT to reflect upon the previous work and investigate the value of a three dimensional medium, such as VR, for conveying ideas which were poorly expressed using other media (such as words, numbers and two dimensional pictures). This collaboration would allow the use of previous BT project work as state of the art case studies. Additionally, working with experts at BT would provide a commercial reality and context, as well as a wider audience from which to validate the research findings.

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[17] Cooper, A. 'Sculptural Metamorphosis', Concept Project for B.A. (Hons) Design for Industry, University of Northumbria at Newcastle, 1995.

[18] Emotional Icons Project, 1992. Undertaken in collaboration between BT Laboratories, Martlesham Heath, Ipswich and Staffordshire Polytechnic.

[19] Fisher, K. et al., Non-Verbal Guidance for Cyberspace Explorers. *British Telecommunications Engineering.* 14 (2), July 1995, p.131.

1.4 Description of the Research's Aims and Objectives

The initial aim of the research was to investigate the hypothesis that three-dimensional interactive imagery could improve aspects of communication in the context of HCI. The secondary aim was to consider the unique virtues of three-dimensional images in relation to the issues involved in communications studies, in order to propose a suitable context for its use and development. From this, the objectives were to determine what aspects of communication were appropriate to different contexts of use, as well as to provide guidelines for the design and development of a protocol for image-based communication.

These early assumptions were refined during the literature search to reflect more accurately the nature of the research and to avoid undue positive bias. In this sense it was felt that the focus on 'improving' and 'virtues' was too one-sided and should be reworded to include potential negative findings. As such, the new aims were to look broadly at the nature of three-dimensional imagery in Virtual Reality for communication. From this it was considered that using theories of communication studies could provide an insight into the different visual attributes of computer graphics. In particular, this would be achieved by investigating different media and their relationship to the overall quality of communication in the digital domain. As such, the aim and objectives were as follows:

1.41 Aim:

By adopting a wide frame of reference, to gain a strategic understanding of the factors influencing the design of Virtual Reality and highlight the opportunities presented by the medium.

1.42 Objectives:

- To identify key characteristics of the Virtual Reality medium, to facilitate design decision-making.
- To provide designers with a framework for considering the relative merits of particular visual graphics within a broader strategic context.

A number of key questions were identified which would specifically address the aims and objectives. These questions can be found in Table 2.

Primary Questions
What is the role of the three dimensional image in Virtual Reality? Can we use an understanding of other media to gain an insight into what Virtual Reality has to offer? What contextual issues surround this new medium? What might its benefits and constraints be?
Secondary Questions
Will it open up new knowledge? What are the implications of not addressing this? How should this issue be pursued in the future? What visual attributes are appropriate for three-dimensional interface and is there value in moving beyond the convention of a mimetic interface?

Table 2: Primary and Secondary Research Questions.

1.5 The Standpoint of the Research

The research was approached from an Industrial Design background, using a designer's perspective. The expertise of the industrial designer in resolving three dimensional form provides a strong skill-set from which to approach the issues involved in the design of Virtual Reality interfaces and three dimensional animation. As noted by Smith:

> "While new media technology is not as revolutionary for humankind as the printing press, it is an extremely powerful method of organising and transmitting information – a method which is both visual and interactive – an information structure well suited to industrial designers."[20]

However, a clear distinction still remains between these two skill-sets. Three-dimensional Virtual Reality representations seem to offer some attributes of physical three-dimensionality, especially the ability to be manipulated and viewed from a variety of angles. However, the tactile aspects critical in the three dimensional world, have not as yet been consistently integrated into the human-computer experience.[21] In particular, the research area was examined using the skills of the designer, namely: visual sensitivity and literacy, problem solving, pattern matching and organisational ability.

[20] Smith, B. H. Working with New Media: Blurred Boundaries; Sharpened Skills. *IDSA Design Education Conference Proceedings*, 1997.

[21] Thalmann, D. Using Virtual Reality Techniques in the Animation Process. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems*. Academic Press Limited, 1993, p.144.

1.6 An Overview of the Research Methodologies used in the Research Project

The chosen methodology for this research was a qualitative one, using case studies and involving interviews, observation and documents as research techniques.[22] The research project methodology will be described below.[23]

An extensive literature search was undertaken which aimed to address human communication needs, the appropriateness of the medium of communication and finally technological advancement. The standpoint for this was based on an arts and humanities philosophy to distil, from a broad source, the relevant issues, paradoxes and dilemmas. This search initially approached a range of subjects including: communication studies (semiotics and semantics), interaction design, information/graphic design, psychology (particularly perceptual psychology), cultural theory, sociology, design theory and issues relating to Human Computer Interface (HCI) and multimedia. This broad foundation was essential as an interdisciplinary study to combine subject excellence from different fields of enquiry. The value of this approach is noted by Kyffin, Senior Director, Philips Design:

> "The value of design research lies in its capacity to draw concrete insights and conclusions from several different knowledge areas, which are not traditionally present in a technology company. The result is an alternative approach to product development and to road mapping the future."[24]

This analysis led to general conclusions and interpretations, which were subsequently refined before being tested through expert and peer review discussions. The conclusion of the literature search included a critical bibliography, a range of propositional papers as well as a tentative communication model. This model mapped the characteristics of different modes of representation based on key concepts from the literature search, in order to create a context for further examining two and three-dimensional digital interfaces.

This primary communication model was subsequently presented at an expert forum organised by the researcher at British Telecom. The forum was seen as a key stage to review and test the findings of the literature search and the resulting model. During the event a range of experts in the field were invited to discuss the issues surrounding the development of the three dimensional media, in particular Virtual Reality. From this, the

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[22] Blaxter, L., Hughes, C. & Tight, M. *How to Research.* Oxford University Press, 2000, p.61.
[23] A full chronology of the project can be found in Appendix 1.
[24] Kyffin, S. In: Cooper, R. & Press, M. *Academic Design Research.* [Online]. Design Council Online Resource, 2004, URL: www.designcouncil.org.uk/design. [June 2004].

model was presented to correlate the findings of the early literature search with state-of-the-art technologies at BT and elsewhere. The key outcome from the forum was a refinement of the model and a definition of key issues and questions to be posed during the case study investigation.

A case study approach was used because of the:

- Contemporaneous nature of HCI development
- Lack of manipulation of the events
- Complexity of the relationship between the chosen representation and the context of use.[25]

For this process, two sets of case studies were investigated: three early case studies - ‘Sculptural Metamorphosis’, ‘Emotional Icons’ and ‘Knowledge=Power’, and three later case studies - 'Call Waiting', 'Concept 2010' and '3D Retail'. Here the researcher acted as an objective reviewer considering the nature of the projects, their outcomes and significance to the research project. As part of the case studies, semi-structured interviews were employed to elicit first-hand data from design practitioners. These interviews consisted of 146 open-ended questions, to lead the experts through their own description of the work. The function of the questions was to ensure the consistent treatment of the different case studies being examined. In addition to the interviews, the case study employed multiple types of evidence, including diaries, videos and documentation to provide the triangulation of data sources.

Between the first and second set of case studies the model of communication was refined and presented to a group of experts for peer review. This Design Research Society (DRS) sponsored event, entitled ‘Multi-viewpoint – Shaping the Human-Computer Interface’, focused on the application of the technologies of VR and three-dimensional imagery from the perspective of the design practitioner.

Following from this, a cross-case analysis was undertaken which resulted in the development of a revised communication model to present the results. This model included examples from practice with the case studies, to correlate the issues raised in earlier models with the findings from the case studies. This integration of theory and

[25] Yin, R.K. *Case Study Research, Design and Methods*. 2nd ed., Sage Publications Inc., 1994, p.13.

practice was critical to test the model with real examples, as well as to present the case studies to design practitioners. This model of communication categorised images and created a visual taxonomy to communicate the theory to practising designers. The resulting 'matrix' indicated possible virtues and constraints as well as the commonalities and differences across media types. From this categorisation, the relationship between the more widely employed mimetic (iconic) interface and the abstract (symbolic) interface was visualised.

Throughout the research a cyclical process of planning, investigation, development and review allowed the refinement of key issues leading to a definitive model of communication. An outline of the key stages of the research can be seen in Figure 1. This diagram of the research process is elaborated in Figure 16.

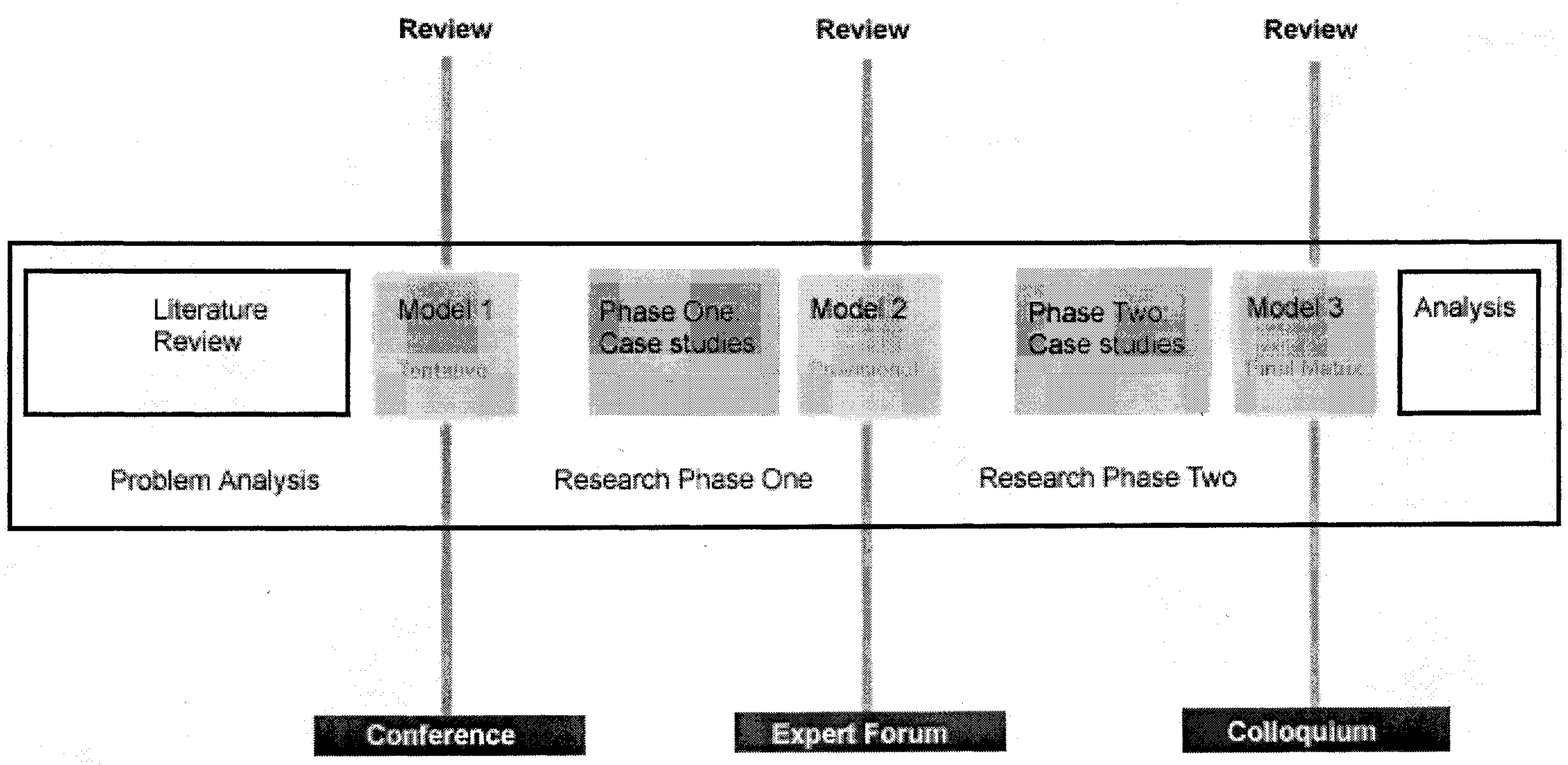

Figure 1: Outline of Research Project

1.7 Contribution to Knowledge

Virtual Reality covers a huge field of study, with different software and hardware as well as a broad range of applications, from scientific visualisation to games design. Due to the significant financial investment often necessary to set up work in this area, research into the subject is undertaken predominantly in universities and state funded research groups, such as NASA and NCSA. In contrast, this research predominantly focuses on commercial Virtual Reality projects designed by BT's interaction designers at Adastral Park, Ipswich. These examples represented state-of-the-art use of VR technology and were conceptually advanced due to the remit of the Interaction Design Futures department within which they were undertaken. Much of the work was years, if not decades, from implementation and yet was still bound by strict financial targets and business-led pragmatics. These well funded, often ambitious examples represent a unique insight into the potential capabilities of the medium. This accessibility of advanced research is a key component of the research project and has determined both the inclusion and omission of certain technologies (see Section 1.8 for details on notable omissions).

Considerable research has been undertaken investigating Virtual Reality and HCI from a computer science perspective, predominantly employing scientific, quantitative methodologies. Other HCI research techniques have focused on psychological or human factors investigations into user responses to media, such as appreciation of colour and text or emotional reactions to interfaces. From this research many of the outcomes have been in the form of generic guidelines for efficient communication of information (such as the discussion about the use of serif versus san serif fonts in text), focusing on individual aspects of the interface regardless of context.

This research differs from previous research, discussed in Chapter 2, in the following key respects: Firstly, it is looking at the research from a 'designerly' standpoint, with the express intention of 'translating' often very theoretical information into a useful model to be applied when designing or evaluating an interface. Secondly, it takes a broader, more theoretical approach, using communication studies and in particular semiotics to identify the virtues and constraints of Virtual Reality, to provide a descriptive insight into the process of communication in this new medium. Finally, it applies a more rigorous methodology in contrast to the empirical work undertaken within the commercial arena and at BT, where time and project pressures often prevent a heavily theoretical or reflective investigation.

The value of the research has been to:

- Consider design content within a strategic, communication centred, framework
- Create and illustrate a mental model for designers to employ to support practice and the process of communication of design intent and content to non-designers
- Highlight trends in empirical practice in HCI
- Consolidate and challenge the value of the approach undertaken at BT
- Champion an appropriate human-centred use of an emergent medium.

1.8 Notable Omissions or Areas Not Covered

The VR and three dimensional media featured in the case studies were designed for use on personal computers (PCs) using mid-range software packages such as Superscape. Internet-based VR software packages such as VRML do not specifically feature in the case studies. Similarly, extremely high-end applications of VR, without cost barriers, which did not reach a wide audience, were also considered a limiting factor as these were not subject to much of the design practice being undertaken. Mobile 3D systems have emerged since 2003 and therefore were not considered as noted in Table 3.

Systems	*Hardware*	*VR Software*	*Examples*
High End	SGI	Division's Dvise	NASA, Flight Simulation, Automotive CAVEs
Mid Range	PC / NT	Superscape	Architectural Visualisation
Low Range	PC	VRML	Games, MUDs, Visualisation
Mobile	PDAs and G3 phones,	Swerve	Games

Table 3: A Breakdown of Virtual Reality Systems.

Within this context, the focus of the research is on the design components or design elements of the mid range system. This comprises the substance of the interface as this is where designers can have a role in developing the medium. Primarily this means the visual attributes of an interface (colour, shape etc), however it also includes the design of three dimensional sound (sonification) and the design of the tactile elements (haptics). The research interview questions, in Appendix 2, include all of these components even though some of the case studies did not contain all of these attributes.

In particular, it should also be noted that although two of the early case studies look at non VR systems, the research is fundamentally centred on the medium of Virtual Reality, focusing on the specific attributes of the medium. These early case studies were used formatively in the construction of questions and more general insights into representation using three dimensional media.

Avatars, or the representation of the user in a virtual world, feature heavily in research looking at representation.[26] However, this research is not covering the visualisation of the

[26] Laurel, B. et al. Placeholder: Landscape and Narrative in Virtual Environments. *Computer Graphics* 28(2), 1994. pp.118-126.

user. It will cover other characters in space, yet not focus on the Avatar specifically. Designers work with the built environment and in this respect this research is focused on the 'substance' of the virtual worlds namely the objects, characters, locations and experience.[27]

Finally, it is acknowledged that technological media, more so than any other commodity, have become 'globalised'. From a global perspective, visual languages pose many interesting cultural questions, however this research scope was limited to Western society, in particular the Anglo-American, English-speaking cultures. Although it notes implications of wider global significance, which are implicit in developing a mode of communication that transcends traditional language barriers, concentration on this aspect was not considered practical for the study.

[27] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design*. Morgan Kaufmann Publishers, 2003, p.406.

1.9 A Summary of the Content of the Thesis

Chapter One introduces the research outlining the aims and objectives, contribution to knowledge and key terms and background.

Chapter Two provides a review of the literature discussing the key issues, dilemmas and paradoxes raised by the research project. This chapter looks at the origins and definitions of the topic, the ontological and epistemological foundations, key sources, theories and debates, as well as standpoints. It also outlines the relevant developments in communication theory as well as the development of different types of media including a critical history of HCI and Virtual Reality. Finally, it looks at realism and abstraction in VR, concluding with a discussion of the key arguments of the research, describing the case for the research in terms of previous work in the field.

Chapter Three reviews the methodological approaches employed in the field of research and highlights their relationship to this research methodology. It also considers the development of design methods more generally and their implications for wider discussions on design practice.

Chapter Four looks in detail at the nature of Design Research. It will consider the development of design methodology, its history and relationship to design methods, theory and practice. The purpose of this section is to define the context of the research, to position the subsequent research methodology in terms of existing paradigms. It concludes by discussing the details of the selected methodologies employed in the research project, including case study and semi-structured interview techniques.

Chapter Five presents the findings of the first phase of the research including the case studies and an expert forum on media and contextual issues. It will describe the primary case studies and the primary communication models.

Chapter Six presents the findings of the second phase of the research including the VR case studies and an expert colloquium on design practice. It will describe the secondary case studies and the secondary communication models.

Chapter Seven interprets these findings by describing the implications of the results in light of other work and providing a critical analysis. It discusses the findings of the research in particular the four key outputs.

- Indication of the virtues and constraints of the medium.
- Illustration of a communication model to provide a taxonomy of the subject.
- General design issues, guidelines and recommendations as an outcome of the research project, including two potential approaches to designing VR.
- A cross-cutting issues template for framing the research questions and results as an outcome of the literature review.

This chapter concludes with a discussion of the integrated outputs of the research by highlighting their value for decision making at both strategic and tactical points in the design process.

Chapter Eight presents the conclusions from the synthesis of the findings from the cross relation of the previous case studies. It summarises the research and links the findings to the original objectives detailing the key contribution. It also highlights the limitations of the research and discusses their impact on the project.

Chapter Nine proposes recommendations for future research and reports the issues beyond the scope of the study. Finally, it provides further reflections on the PhD study.

CHAPTER 2.0: REVIEW OF THE LITERATURE

To exemplify the current state of the field, a review of the major issues and debates, quotations and projects being undertaken in human-computer interface, Virtual Reality, design and communication studies was undertaken. In particular, this highlighted the major questions and problems that have been addressed by existing research as well as revealing more specifically the opportunities that exist for further research. What follows is a synopsis of these findings.

2.1 Background

The relationship of man to technology has been pivotal in the development of modern thinking and experience, extending human senses and capabilities.[28] Technology in many respects has been seen to be an indicator of the development of human thinking within a particular culture, modifying not only the physical environment, but also individual's conceptual systems of representation. The modern technological era has resulted in the emergence of the post-industrial,[29] information society[30] or knowledge economy.[31] Within this context, much of our communication is mediated by technology with the computer interface presenting new opportunities for communicating ideas. Here the notion of interface relies on the idea of the spatial division between 'body' and 'machine'. The human-machine, which would subsequently develop into a concept of the human-machine interface, or human-computer interface, is based on this premise.[32] This is noted by Garner, when he suggests that:

> "Increasingly, industrial designers work at the 'interface' between people and things, and at the interface between disciplines... to develop clear, logical, and usable displays and instructions—that is, the interface (interaction) between users and products."[33]

In this construct the user is seen as technology's 'audience', experiencing it from a distance, with information flowing in a linear manner from one to the other, as it might to

[28] McLuhan, M. *Understanding Media, the Extensions of Man*. Routledge, 1995. p.7.
[29] Moles, A. Design and Immateriality: What of it in a Post Industrial Society? *Design Issues*, 4 (1&2), Special Issue, 1988, p.25.
[30] Lyon, D. *The Information Society*. Blackwell, 1988.
[31] The term 'knowledge economy' was coined in 1969 by the American social scientist Peter Drucker.
[32] Broadhurst Dixon, J. & Cassidy, E.J. (eds.) *Virtual Futures: Cyberotics, Technology and Post-Human Pragmatism*. Routledge, 1998, p.x.

an audience at the cinema. However, as technology has become both smaller and more complex, the idea of a user as audience existing separately in space has been increasingly questioned. With this miniaturisation, technology has migrated physically towards, onto and into the body. As Cochrane notes: "Just a small slice of silicon under the skin is all it would take for us to enjoy the freedom of no cards, passports, or keys."[34] With the removal of a simple dichotomy between audience and technology comes the potential for the user to be fundamentally participatory, enveloped by the machine in a 'fully immersive' mind-body experience. In VR this breakdown of the audience-technology barrier, was enabled by the development of head-mounted displays. As Hillis notes: "HMDs influence the perceptually defined relationship ...between spectators and image, scene, or landscape."[35] However, this portability of technology is a relatively recent development and VR has its roots much earlier at a time when computers filled a room and the goal of the system was to imitate the fullness of reality.

[33] Garner, S. *Microsoft Encarta Encyclopedia* 2003. 1993-2002 Microsoft Corporation.
[34] Cochrane, P. *108 Tips for Time Travellers.* Orion Business Paperbacks, 1997, p.7.
[35] Hillis, K. *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality.* University of Minnesota Press, 1999, p.10.

2.2 The Historical Development of VR

In 1956 Morton Heilig invented the film-based Sensorama, a system designed to completely replace the senses with an artificial experience. Heilig's vision was to create three-dimensional images, sound and scent to manufacture the ultimate film experience where the viewer's sensory engagement was controlled. This work, although ambitious in its scope, was marginalised due to lack of funds.[36] In 1965, Ivan Sutherland presented his paper "The Ultimate Display"[37] which hypothesised the creation of a 'transparent' three-dimensional head mounted display (HMD). Following from his PhD thesis "Sketchpad: A Man-Machine Graphical Communication System," published in 1963, Sutherland was widely credited as the inventor of the concept of Virtual Reality.[38] Of fundamental importance to the work of Sutherland and others including Philco Corporation, who developed a head-mounted display in 1958,[39] was the idea of stereoscopic vision. Following from this work, Sandin, Zimmerman,[40] Fisher and Lanier[41] all produced gloves for tactile instruction, which could be utilised with the HMDs, leading ultimately to Data Glove™ by VPL Research.[42] After creating the glove, Fisher and Lanier later went on to develop EyePhone,[43] the first commercial helmet. However, it was Lanier who was to give Virtual Reality its name, with the Japanese referring to it as 'Intimate Presence' and Kruger preferring the term artificial reality (AR).[44]

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[36] Hillis, K. *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality.* University of Minnesota Press, 1999, p.8.
[37] Sutherland, I. *The Ultimate Display.* Proceedings IFIP Congress, 1965, p.506.
[38] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.33.
[39] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.33.
[40] Rheingold, H. *Virtual Reality: Exploring the Brave New Technologies of Artificial Experience and Interactive Worlds from Cyberspace to Teledildonics.* Quality Paperbacks Direct, 1991, p.137.
[41] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.36.
[42] Thalmann, D. Using Virtual Reality Techniques in the Animation Process. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.144.
[43] Pimentel, K. and Teixeira, K. *Virtual Reality: Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.74.
[44] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.38.

2.3 Definition of Virtual Reality

Virtual Reality (VR) describes the concept of a computer interface (software and hardware system) that provides users with a replacement sensory experience (visual, sonic and haptic). Hillis puts it simply: "VR is a technological reproduction of the process of perceiving the real."[45] This representation may partially obscure the 'real world' as with Augmented Reality (AR) or may be fully immersive, completely blocking out the real world. The substance of VR is typically a Virtual World that can be run on a VR system comprised of a computer and specialist equipment such as head-mounted displays (HMDs), sensors and input devices.

VR has specific qualities that define it in relation to other media using three dimensional representations, such as, film, television and animation. Fundamentally, it is in the generation and control of a real-time interface that VR is distinguished. Sherman suggests that the essence of Virtual Reality lies in what he describes as the five 'I's: intensive, interactive, immersive, illustrative and intuitive.[46] As he notes: "It is the user's inclusion in this illusionary world, and the ability to influence what happens in it, that makes all the difference between Virtual Reality and ordinary computing, the movies, television or art."[47] Therefore, Virtual Reality refers to a three-dimensional, computer-generated, simulated environment that is rendered in real time in response to a user's behaviours.[48]

2.3.1 The Virtual Reality Medium

The qualities of VR are central to this research which look at the attributes of the medium in relation to other design options. Some work has been undertaken to look at this issue. According to Erenay:

[45] Hillis, K. *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality.* University of Minnesota Press, 1999, p.xiv.
[46] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.156.
[47] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.157.
[48] Loeffler, C. & Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.xiv.

"Regardless of the VR type and VR system, the following advantages can be obtained by using VR:

1. They provide a sense of scale, from motion parallax and the stereo view
2. There is ease of interaction with complex components using 3D input devices
3. Skill acquisition is improved
4. It is a unique way to study complex interactions
5. Improved understanding is gained through direct interaction."[49]

Similarly, reasons to use VR according to Sherman include:[50]

- Improved ability to examine and explore 3D data
- Improved quality of life
- Convey ideas as informative expression
- Marketing
- Safety
- Non invasive experimentation and other simulation techniques
- Cost saving.

VR surveys (1994, 1995) by the Advisory Group on Computer Graphics (AGOCG) requested information from UK practitioners and researchers about 'the perceived main benefits of VR', however, they acknowledge that the research findings were formative, as Howard notes: "The extent to which this remains an expectation rather than proven benefit remains unclear."[51] Stapleton's survey of 1997 suggests three themes to cover VR's benefits including: VR as Intuitive/naturalistic, diversity of audience and economic benefits.[52] These studies included a good cross-section of UK research at the time, giving an indication of the hardware, software and funding streams. However, the user responses on specific benefits of VR lack in-depth rigor as they are not based on a common methodology or context for investigation, i.e. what is a benefit in one field may not be in another. In this respect, many studies avoid asking generic questions about the virtues of VR across disciplines, preferring to look at specific contexts for use and the associated benefits.[53] This research, however, is looking in depth at specific case studies to draw conclusions from design practice and position these within a theoretical context.

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[49] Erenay, O. & Hashemipour, M. Virtual Reality in Engineering Education: A CIM Case Study [Online]. *The Turkish Online Journal of Educational Technology.* Vol 2, Issue 2, Article 8. April 2003. p.3. URL: http://www.tojet.net/articles/228.htm. [July 2004].

[50] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003. p.412-3.

[51] Howard, T. L. J, et al. *1995 Survey of Virtual Reality in the United Kingdom,* Prepared for the Advisory Group on Computer Graphics, 1995 [Online]. p.8. URL: www.agocg.ac.uk. [May 2004].

[52] Stapleton, L. J. & Costello, P. J., *A Survey of Virtual Reality Research in the UK 1997* [Online]. p.10. URL: www.agocg.ac.uk. [July 2004].

2.3.2 Application of VR and HCI

VR is an emergent medium and opinion is divided about how to classify the field, with more areas likely to emerge over the coming years. Schneiderman suggests a broad range of applications of HCI broken down into four primary sources: life-critical systems; industrial and commercial uses; office, home, and entertainment applications; and exploratory, creative and collaborative systems.[54] Gigante suggests a subset of this for Virtual Reality applications which are suited to the medium's properties including: Operations in hazardous or remote environments; scientific visualisation; architectural visualisation; design; education and training; computer-supported collaborative work (CSCW); Space exploration and entertainment.[55] Sherman notes the following problem areas for VR application:

- Inherently three dimensional tasks (e.g. Architectural simulation)
- Problems that cannot be tackled in the physical world (e.g. visualisation of nanotechnology)
- Problems that cannot be experimented with due to cost constraints (e.g. aircraft flight simulation)
- Problems in 'what if?' studies where virtual exploration could lead to better understanding (e.g. Fire escape simulations under varying conditions)
- Problems that cannot be studied safety (e.g. nuclear plant design).[56]

Rowley meanwhile categorises applications of VR as: entertainment; training of various kinds; therapy for a number of physical and mental disorders; promotion and sales; and information interface for libraries and other data stores.[57] Existing applications of three dimensionality and Virtual Reality representation include:

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53 Bouchlaghem, N., Khosowshahi, F. & White, J. Virtual Reality as a Visualisation Tool: Benefits and Constraints. *CIDAC*, 2(4), November, 2000, p.216-224.

54 Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.19.

55 Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.8.

56 Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003. p. 417.

57 Rowley, T. Virtual Reality Products. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.45.

1. Simulation (scientific visualisation, architectural visualisation, complex process mapping, scenario modelling, weather forecasting)
2. Design development (form-fit functionality, user-centred design, animation)
3. Entertainment (games (arcade/home/internet based games), planetariums, museums).
4. Training (medical training, flight simulation, (military & commercial))
5. Collaborative environments (tele-medicine, user-centred interaction, virtual conferencing, multi-user domains (MUDs), multi-user domains object-orientated (MOOs), computer supported collaborative work (CSCW)
6. Sales (internet shopping, mass customisation, design visualisation)
7. Artistic exploration (e.g. *Osmose,*[58] *The Legible City*[59]).

This research is looking at case studies featuring simulation, training, collaborative environments and sales, where the purpose of the medium is predominantly to communicate an intended meaning. In contrast, research into design process is by its nature more goal-orientated, whereas games, entertainment and artistic exploration are more aesthetic. The use of VR in telemedicine, medical visualisation and therapy developments has been a significant application of the technology, but is not specifically featured in this research.

[58] Osmose was exhibited in Newcastle at the Laing Art Gallery, Newcastle, in February 1997, when the researcher took part in using the system. The exhibition formed part of the Serious Games exhibit curated by Dr. Beryl Graham of Sunderland University. Osmose was later shown at *Transfigure: Perception, Body, Space & Landscape Transformed by the Moving Image*, Melbourne ACMI. March 2004.

[59] Shaw, J. et al. *The Legible City 1989.* [Online] URL: www.jeffrey-shaw.net [July 2004].

2.4 VR Hardware Systems

There are a number of types of Virtual Reality technologies and techniques available to the designer including: desktop or fish tank VR, augmented reality and fully immersive VR (all systems can be used with or without haptic controls). How the designer utilises these technologies varies, each having their own benefits and constraints, and in particular their own associated costs.

2.4.1 Immersive VR

Immersive VR is sometimes considered the only type of VR, as epitomised in films such as Lawnmower Man, Disclosure and The Matrix. It refers to VR systems with headsets or projection systems that provide a near complete sensory replacement reality. The key element of such systems is the exclusion of the real world from the experience, making the user appear to be 'in' the digital space. Additionally, data gloves and head mounted displays are often used to increase the sense of immersion. Most of the developments in VR have stemmed from military research at organisations such as NASA Ames Research Centre, where flight simulation software pioneered early developments of Virtual Environments. Within art, Char Davies experimented with immersive VR with the creation of Osmose, a fully interactive VR experience with a body suit and surround sound. These systems tend to be both sophisticated and costly.

2.4.2 Augmented Reality

Augmented reality (AR), sometimes referred to as mixed reality (MR), refers to the overlaying of digital information onto real-world images or contexts. Augmented reality is often used in conjunction with Cave Automatic Virtual Environments (CAVEs) to allow users to be put in physical environments with VR information. The development of the CAVE interface was pioneered by Sandin, DeFanti and Cruz-Neira, whilst working at the Electronic Visualisation Laboratory (EVL) of the University of Illinois.[60] This work, more so than other VR systems, is based on the ideas contained in Plato's Republic as Sandin notes:

"While the name suggests the system's physical appearance, it is intended more strongly as an allusion to the Allegory of the Cave found in Plato's *Republic.* Here the Greek philosopher explored the ideas of perception, reality and illusion, using the analogy of a person facing the back of a cave alive with shadows that are his only basis for his ideas of what real objects are."[61]

A key benefit of the CAVE is the elimination of heavy headsets and data gloves[62] as well as a reduced need for modelling, as many parts of the system are real. AR is increasingly being used in the automotive industry for computer aided production engineering (CAPE), to enable the production of virtual prototypes before a physical prototype is built.[63] Within medicine, AR is also utilised to enable medical students to train for procedures, for example complex keyhole surgery utilising unfamiliar equipment and testing a number of different situations.[64] Figure 2 illustrates the Reality-Virtuality Continuum as suggested by Milgram. From this we see at one extreme 'Real Environments' and at the other extreme the 'Virtual Environment', with 'Mixed Reality' (MR) forming a hybrid in between.

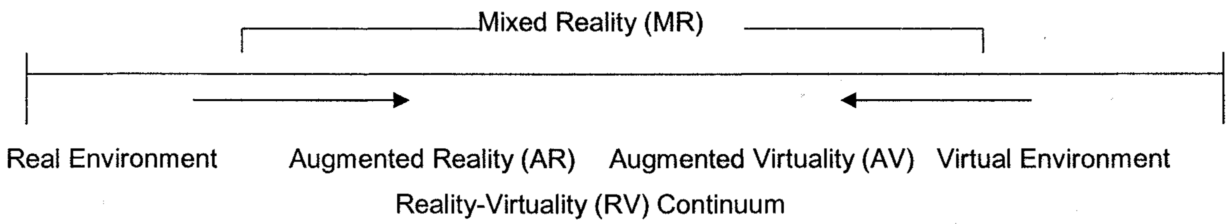

Figure 2: An Illustration of Mixed Reality. Milgram, 1994.

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[60] Cruz-Neira, C., Sandin, D. & DeFanti, T. Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE. *Siggraph 1993 Conference Proceedings.* 1993, p.135-142.
[61] Sandin, D., Defanti, T. & Cruz-Neira, C. *A Room with a View.* Spectrum, October 1993, p.30.
[62] Packer, R. & Jordan, K. (eds.) *Multimedia: From Wagner to Virtual Reality.* W.W. Norton & Company Ltd., 2001, p.268.
[63] Penndorf, W. Representing Reality: Virtual Reality in Automobile Manufacture. *Multiviewpoint: Shaping the Human Computer Interface.* Design Research Society Conference, Centre for Design Research, Newcastle, July 02, 1998. [unpublished].
[64] Yagel, R. et al., Multisensory Platform for Surgical Simulation. *IEEE Virtual Reality Annual International Symposium (VRAIS'96),* 1996, p.72.

2.4.3 Desktop VR

Desktop VR, also known as Fish tank VR, utilises a PC and flat-screen monitor. As the most basic form of VR, it has widened participation and reduced cost and complexity for users. The graphics capability of PCs has been improved by their dominance in the games market, with organisations such as nVIDIA using the same processing power to manipulate polygons in computer games as are used in the UNIX industry to manipulate VR. This transfer of technologies has allowed traditional PC manufacturers to invade the high-end VR / CAD market. Current desktop computers therefore form a low cost, yet capable system for running virtual worlds. Utilising these hardware systems, Superscape and VRML software is capable of delivering relatively sophisticated graphics running on low specification PCs. The important distinguishing element of Desktop VR is that the user illusion can be broken, simply by turning away from the screen.

Virtual worlds can be run on any of these hardware systems and can usually be migrated from one to another i.e. an immersive system can be displayed on a flat computer screen with a few adaptations. The main criteria for choice of hardware is often cost, followed by the level of immersion required.[65] In this research, Desktop VR systems have been used as these systems were used in the BT case studies and represent the most accessible form of VR for most practicing designers[66] (see Section 1.8 for further discussion).

2.4.4 Technological Determinism

Determinism refers to the influence of external conditions, which in some way fix the course of a process or event.[67] In particular, technological determinism refers to the influence of tools and techniques on a particular outcome. This section will briefly discuss the consequences of determinism for the development of the VR content. Two forms of determinism were likely to affect the case studies in this research, these included financial and technological. Moore's Law refers to predictions made by Gordon Moore in 1965 that

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[65] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003. p.413.

[66] Howard, T. L. J, et al. *1995 Survey of Virtual Reality in the United Kingdom*, Prepared for the Advisory Group on Computer Graphics, 1995 [Online]. URL: www.agocg.ac.uk. [May 2004]. Followed by Stapleton, L. J. & Costello, P. J., *A Survey of Virtual Reality Research in the UK 1997* [Online]. URL: www.agocg.ac.uk. [July 2004].

[67] Bullock, A., Stallybrass, O. & Trombley, S. (ed.) *The Fontana Dictionary of Modern Thought.* 2nd ed. Fontana Press, 1988, p.847.

the capacity of the computer chip would double every year.[68] He co-founded Intel with Bob Noyce, and microprocessors have continued to approximately double in transistor count every eighteen months. Although most VR systems are relatively crude in visual terms, indications are that this constraint will be alleviated by the growth of computer power and size reduction and, as such, many existing technical flaws will be eliminated in due course.[69] Aligned to this, technological determinism is also evident in the software available to the designer. Here VR software often contains 'clip art' objects, which are pre-modelled and form a limited choice. These ready-made models are widely used by designers to speed up the production of a virtual environment and in some cases can be seen as an aesthetic compromise.

[68] Gates, B. *The Road Ahead.* Penguin Books Ltd., 1996, p.34.
[69] Mallen, G. Back to the Cave: Cultural Perspectives on VR. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.268.

2.5 Making Meaning in VR

Following the consideration of the nature of VR as a technological medium, this section specifically looks at the issues raised when designing a three-dimensional Virtual Reality experience. Designing for digital three-dimensionality involves a combination of skills and has both philosophical and practical implications. Beyond the technical production of the sensory illusion using hardware, there are numerous ideological issues raised by VR, in particular about the substance of the experience, or in other words, about what you choose to represent. To look at these issues requires many of the fundamental assumptions associated with this emergent medium to be analysed and scrutinised. This is important, as clearly these are design questions which have significant implications for the quality of the VR experience across the spectrum from usability to aesthetics. And yet to date, nearly all development in VR has been undertaken by scientists and artists whose objectives and approaches are very different from those of the designer. This research is interested specifically in the designer's contribution to the development of VR, yet given this has been relatively limited to date, [70] much of the analysis has been of debates and discussions in computer science, mathematics and, to a lesser degree, the arts.

From a design perspective, Bolas notes three key categories of design in VR as described in Figure 3.

- Design <u>with</u> virtual environments refers to the use of virtual reality to help solve a problem or invent something new.
- Design <u>for</u> virtual environments refers to the task of improving the hardware and software of VE systems themselves.
- Design <u>of</u> virtual environments is the creation of completely synthetic environments, or virtual worlds.[71]

Figure 3: Design Process and Virtual Environment (VE) Systems According to Bolas.

[70] Howard, T. L. J, et al. *1995 Survey of Virtual Reality in the United Kingdom*, Prepared for the Advisory Group on Computer Graphics, 1995 [Online]. URL: www.agocg.ac.uk. [May 2004].
[71] Bolas, M. Designing Virtual Environments. In: Loeffler, C. and Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.49.

In terms of these criteria, the research is specifically looking at the design *of* virtual environments, using examples of practice as case studies. However, the findings will contribute to an understanding of designing *with* virtual environments in terms of a taxonomy of practice.

2.5.1 Communication using Signs

The effective design of Virtual Worlds involves a choice of representation to communicate an intended message to the user. Ann Tyler suggests that audience considerations are integral components of the process of visual communication. Noting that the goal of all communication is to accomplish one of the following:

- To induce the audience to take some **action**
- To **educate** the audience (persuade them to accept information or data)
- To provide the audience with an **experience** of the display or exhibition of a value for approval or disapproval, values with which the audience may wish to identify or may wish to reject [bold text is the author's original emphasis].[72]

In this sense, VR is a medium for communication and can be considered in these terms. If we examine communication we see the origins of some of the most fundamental systems of reconciling experience. Primarily, it is our systems of classification and categorisation that allow us to objectify the world and assign names to collections of experience. In this way we learn to divide the world into myself and others, chairs and tables and so forth.

From the most basic sensory interactions it can be seen that individuals make structures and concepts that enable them to reach higher conceptual levels and thereby facilitate unambiguous communication. Semiotics, broadly speaking, is a mode of knowledge of understanding the world as a system of relations, it therefore studies the nature of representation. Fiske notes that it has three main areas:

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[72] Buchanan, R. Declaration by Design: Rhetoric, Argument and Demonstration in Design Practice. In: Margolin, V. (ed.) *Design Discourse: History Theory Criticism.* The University of Chicago Press, 1989, p.92.

1. The sign.
2. Codes or systems.
3. The culture.[73]

Thus, the world is grouped into systems, divided into binary oppositions and structured into hierarchies of meaning. This mechanism takes the world as an unrecognisable mass and breaks it down to enable concepts to be considered. Communication inherently involves aspects of experience, being converted into a different form, a form that is known as a Sign. Pierce describes the different association of a sign to 'its object' as either an icon, index or symbol (Figure 4). An icon refers to a sign that resembles its object in some way, such as a picture of a fire. An index is related to its object by an existential connection, in the way smoke is associated with a fire and finally the word 'fire' itself is a symbol, as we have learned to understand it through convention.

Icon **Index** **Symbol**

Figure 4: Icon, Index and Symbol
(Adapted from Frutiger, A. *Signs and symbols* 1989).

Saussure describes these as either iconic, when the signifier looks or sounds like the signified, or Arbitrary, where the signifier and signified are related only by agreement by its users.[74] Some signs may be closer than others to their signified, however, the sign can never be the original. Saussure suggests that the relationship between the signified and the signifier can be referred to as its motivation.[75] Thus, a highly motivated sign is an iconic one, with an arbitrary sign being unmotivated (see Figure 5). This motivation of signs refers to the level of constraint that the signified has over the signifier. In this diagram,

[73] Fiske, J. *Introduction to Communication Studies*. 2nd ed., Routledge, 1995, p.40.
[74] Saussure, F. de *Course in General Linguistics*. Duckworth, 1995, p.67.
[75] Saussure, F. de *Course in General Linguistics*. Duckworth, 1995, p.130.

convention refers to the 'social dimension' of the sign, in that it is the agreement amongst users about the appropriate use of a particular sign.[76]

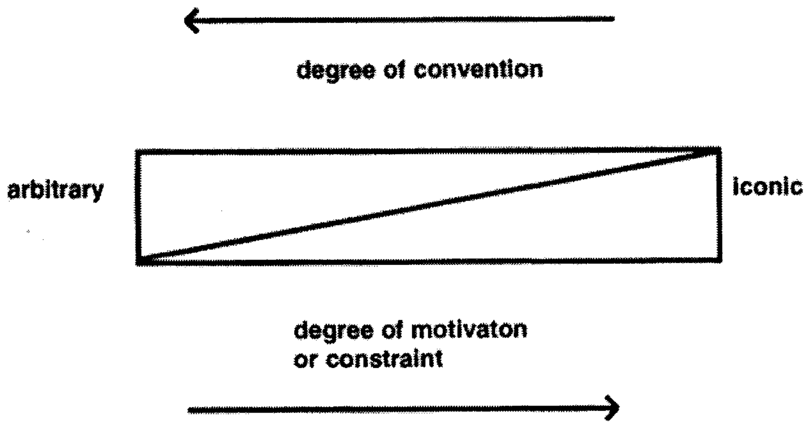

Figure 5: Levels of Motivation between Iconic and Arbitrary Signs.

Often, the way we understand signs, whether they be iconic, indexical or symbolic, has become so familiar that we fail to see the underlying illusion (Figure 6).

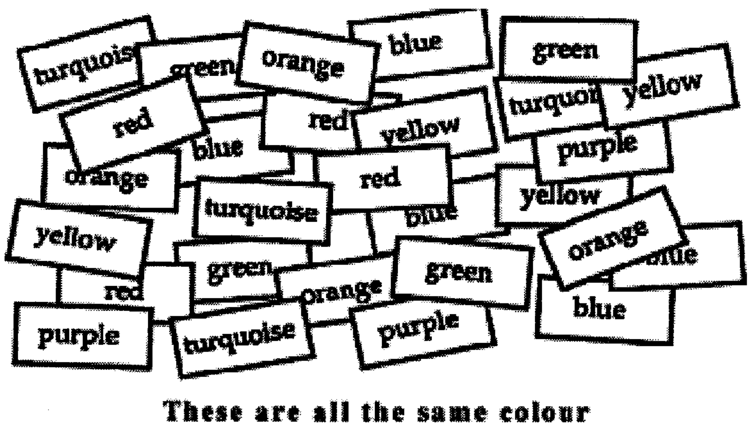

Figure 6: The Classification of Colour.

In order to derive meaning from the real world we translate such signs into meanings. Nevertheless, how we read these representations depends on our systems of signs (our interpretant). What this also highlights is that the same image can create different

[76] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.56.

meanings and thus the same meaning can be communicated by many different images. Subsequently, as Frutiger notes:

> "Understanding what a thing represents - as opposed to merely what it depicts - is a prerequisite for using the sign correctly, since the same physical representation can be used in many signs."[77]

With the application of an increasing 'structure' within cultures, individuals are often under the false impression of thinking that their perception of events (personal construct or lexicon) is representative of the world at large. "Paradigms are powerful because they create the lens through which we see the world."[78] Fiske notes that all messages involve a selection (from a paradigm) and combination (into a syntagm). For example the way a sentence (syntagm) is constructed from sets of words (paradigm), or the way that 'red and yellow' (syntagm) might be selected from a range of possible colour combinations (paradigm) in traffic lights. As Fiske notes: "All the units in a paradigm must have something in common; they must share characteristics that determine their membership of that paradigm."[79] In this sense perception of reality involves making sense of data in terms of paradigms and syntagms by identifying differences in the things being perceived and forming relationships. The ordering of signs into systems can be described as codes. The power of this ordering, although often inconspicuous, is considerable. It is the interface designer who is in a key position to order the computer user's experience, by converting raw perceptual data into culturally coherent interfaces. As Fiske notes:

> "All codes rely on commonality, an agreement amongst their users on their basics – the units they contain, the rules by which these units may be selected and combined, the meanings open to the receiver, and the social or communicative function they perform."[80]

However, once it has been reconstructed in the mind of the viewer, the author has no control over the process, as Forest suggests;

> "...the observer can always notice the presence of certain elements (physical) or signs (visible or audible) which, by a process of mental projection, lead him to reconstitute the overall representation."[81]

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[77] Frutiger, A. *Signs and Symbols: Their Design and Meaning.* Studio Editions, 1989, p.174.
[78] Covey, R. *The Seven Habits of Highly Effective People.* Simon and Schuster, 1992, p.32.
[79] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.57.
[80] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.77.
[81] Forest, F. Communication Esthetics, Interactive Participation and Artistic Systems of Communication and Expression. *Design Issues,* 4(1&2), Special Issue. 1988, p.108.

Communication involves converting experiences into a different form that merely *re-presents* the original. The observer is then the receiver of the message, as Anne Tyler notes: "The goal of all communication is 'to induce in the audience some belief about the past..., the present..., or the future.'" [82] The idea of 'some belief', not necessarily what was intended, allows for discrepancies in the message between individuals. From this perspective modern society has a number of methods of re-presenting ideas, utilising a number of different media. The following section will look in particular at VR as a means of conveying ideas, the implications of choice of signs and the codes developed to date, including VR as a language.

[82] Buchanan, R. Declaration by Design: Rhetoric, Argument and Demonstration in Design Practice. In: Margolin, V. (ed.) *Design Discourse: History Theory Criticism.* The University of Chicago Press, 1989, p.92.

2.6 The Aesthetics of Virtual Reality

In VR the visual, audio, kinaesthetic and olfactory signs combine to form an overall aesthetic experience. At a detailed level this sensory information can be divided into sub-modalities, for example vision can be broken down into colour, brightness and pattern. As Pimentel suggests: "representational systems and their sub-modalities are the building blocks of experience to which meaning is applied."[83]

Graphic representation in VR is important as it is often seen as the primary sense. As Berger suggests, seeing comes before words.[84] The Virtual Reality medium can display a number of types of graphical representations. However, the way different forms of image portray a particular concept has implications for effective communication. In a discussion of the development of HCI, Kay suggests that when presented with information, the senses receive it through different channels in different ways, for example sound or sight.[85] With images, particular preferences may occur, as the painter Magritte plays with different concepts of signs, highlighting the power struggles between different types of representation in his painting *Key of Dreams* (Figure 7).

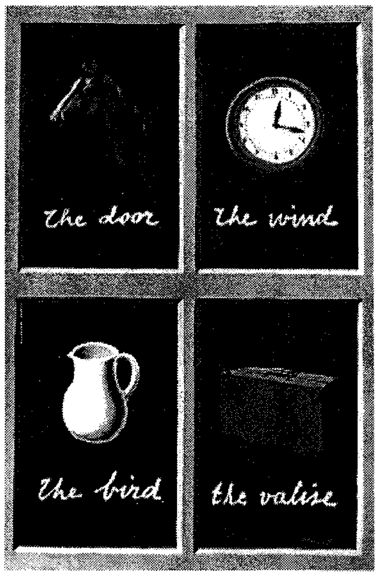

Figure 7: Magritte, Key of Dreams
(From Gablik, S. *Magritte.* Thames & Hudson, 1992).

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[83] Pimentel, K. and Teixeira, K. *Virtual Reality: Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995. p.211.
[84] Berger, J. *Ways of Seeing.* Penguin Books, 1972, p.7.
[85] Kay, A. *Doing with Images Makes Symbols: Communicating with Computers.*97 min. Industry Leaders in Computer Science: Distinguished Lecture Series. Apple Computer Inc., 1987. Videocassette.

The meaning of images can be confusing, as Barthes notes: "They imply, underlying their signifiers a floating chain of signifieds, the reader able to choose some and ignore others."[86] This has been described as the polysemous nature of visual images.

Invariably VR will contain both two and three dimensional graphics and how these are combined is left to the discretion of the designer or developer. However, different dimensionality has different affordances which should be considered because of its effect on the users' understanding and the overall coherence of the interface.

2.6.1 Two Dimensional Images in Human-Computer Interface

Xerox's Palo Alto Research Center (PARC) work of the 1970s established many interface conventions, and led directly to work undertaken at Apple on the Macintosh graphic interface. It pioneered concepts such as multiple overlapping windows, to divide activities on display, as well as on-screen graphic metaphors for objects, programs and documents;[87] windows, icons, menus, pointer (WIMP); what you see is what you get (WYSIWYG); and the principle of 'feedback' which suggests that the computer interface should give clear and immediate feedback of actions that the user makes. Such examples of physical or visual responsiveness changed the user's perspective of technology from being controlled at a distance to being instantaneous and invisible. Rutkowski refers to this as the principle of transparency, with Nelson raising the principle of virtuality. The consequential change in the user's qualitative experience of using machines was also attributable to the coherence and consistency of the interfaces. Coleridge's concept of "willing suspension of disbelief", a term coined to describe the experience of audiences in theatrical plays, aimed to describe greater levels of engagement, and seems similar to Laurel's concept of the computer as theatre:

> "For the audience member who is engaged by and involved in the play, the action on the stage is *all there is*. In this sense plays are like movies: When you are engrossed in one, you forget about the projector, and you may even lose awareness of your own body."[88]

[86] Fiske, J. *Introduction to Communication Studies*. 2nd ed., Routledge, 1995, p.110.
[87] Lynch, P. Visual Design for the User Interface, Part 1: Design Fundamentals. Yale Centre for Advanced Instructional Media. *Journal of Biocommunications*. 21(1), 1994, p.23.
[88] Laurel, B. *Computers as Theatre*. Addison-Wesley Publishing Company, 1993, p.16.

However, it was the Graphical User Interface (GUI) that defined the interaction with the computer and emancipated the computer operator from binary code and programming. As Frutiger remarks on the impact of images on the HCI environment:

> "Few would argue that images are not among the most important elements in a visual computing environment. Their impact on the presentation of a conceptual model, the tightness of the feedback loop between person and machine and the apparent tangibility of a synthetic virtual space is greater than any other aspect of the application."[89]

With images, the association between the sign and the signified can be so strong the illusion appears seamless. As Lynch notes, "The graphic interface directs, orchestrates, and focuses the user's experiences, and makes the organisational structure of the computer system or multimedia document visible and accessible to the user."[90]

Early interface designers relied on monochrome two-dimensional images and text to convey ideas about the operating system (OS). The wastebasket (Figure 8) is an example of a computer icon which was graphically simplistic in order to keep file sizes low enough to maximise limited computer memory.

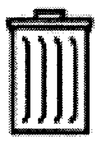

Figure 8: Apple Wastebasket in 2D.

These icons are reminiscent of designs still prevalent in Eastern Art and characteristic of pre-renaissance visualisation. In these examples, linear perspective is absent in representation with images existing in space in a stylised manner.[91]

In addition to simple icons, the development of GUIs utilised significant amounts of text based communication (TBC). This combining of signs, often called 'redundancy' in multimedia, describes circumstances where an image is also presented with a textual description to backup the communication. Hillis, suggests this is: "Because images are arguably more directly received than abstract text, they are subject to a wider range of

[89] Frutiger, A. *Signs and Symbols: Their Design and Meaning.* Studio Editions, 1989, p.170.
[90] Lynch, P. Visual Design for the User Interface, Part 1: Design Fundamentals. Yale Centre for Advanced Instructional Media. *Journal of Biocommunications.* 21(1), 1994, p.23.
[91] Ashcroft, J. & Odam, J. *Getting Started with 3D: A Designer's Guide to 3D Graphics and Illustration.* Peachpit Press, 1998, p.10.

individual interpretations; their meanings are policed (through the use of text), fought over, and subject to change."[92] In communication studies the term 'Anchorage'[93] has been used to describe the relationship of text to image, in tying down meanings. This has also been referred to as 'Denomination' by Barthes.[94] In this sense, words help "fix the floating chain of signifieds in such a way to counter the terror of uncertain signs."[95] Yet it is important to note that words do not exist as a separate category from images, as they are symbolic images that users have been 'educated' to decipher. Within the computer environment words are predominantly represented without perspective in a linear manner as demonstrated in Figure 9.

Waste Paper Basket Dust Bin Trash Can

Figure 9: Text-Based Communication illustrating a similar concept (TBC).

Although words may be suitable for many applications, they cannot express some things as effectively due to their inherent form. As Marshall McLuhan highlights in *Understanding Media*:

> "All the words in the world cannot describe an object like a bucket, although it is possible to tell in a few words how to make a bucket. This inadequacy of words to convey visual information about objects was an effectual block to the development of the Greek and Roman sciences."[96]

In contrast, perspective appears closer to reality as it reproduces the binocular elements of the human visual system. Schirato, extends this in suggesting that images do not appear to be mediated because their own materiality appears close to the materiality they stand for. In this sense however, he suggests words are experienced differently from images. "Visual

[92] Hillis, K. *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality.* University of Minnesota Press, 1999, p.136.
[93] Barthes, R. *Image-Music-Text.* Hill & Wang, 1978, p.39.
[94] Barthes, R. *Mythologies.* Hill & Wang, 1973, p.146.
[95] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.110.
[96] McLuhan, M. *Understanding Media.* Routledge, 1964, p.158.

texts do not appear to be mediated: there appears to be no obvious difference between the image the text provides and the 'reality' it stands for."[97]

2.6.2 Use of Perspective in Human-Computer Interface

As chip speeds improved and computers became more powerful, designers were increasingly creating three-dimensional images utilising perspective in the GUI. These images were based on techniques developed during the renaissance, when artists and scientists experimented with systems for creating linear perspective.[98] To create believable perspective, renaissance artists manipulated key elements to create perspective including the creation of a horizon, vanishing point, viewpoint, line of sight and picture plane, visual rays and foreshortening.[99] Computer artists used the same principles in the human-computer interface, as exemplified by the illustration of the Apple wastebasket in Figure 10.

Figure 10: Apple Wastebasket: In Perspective Anchored by Words.

Yet reading and understanding perspective is a learnt skill,[100] involving interpretation and a decoding process, which most computer users take for granted.

[97] Schirato, T. & Yell, S. *Communication and Culture: An Introduction.* Sage Publications Ltd., 2000, p.166.
[98] Ashcroft, J. and Odam, J. *Getting Started with 3D: A Designer's Guide to 3D Graphics and Illustration.* Peachpit Press, 1998, p.10.
[99] Ashcroft, J. and Odam, J. *Getting Started with 3D: A Designer's Guide to 3D Graphics and Illustration.* Peachpit Press, 1998, p.10-11.
[100] Csikszentmihalyi, M. Design and Order in Everyday Life. *Design Issues,* 8(1), Fall 1991, p.31.

2.6.3 Three Dimensional Animation

Beyond static images, animation is now widespread in the GUI for conveying ideas to computer users. Animation relies on the addition of time to the experience of image. As with the use of perspective, it is necessary to create the illusion of three-dimensionality beyond static representations. Here the interaction with the image may appear to reveal a multifaceted view of the object, replicating the user's ability to move in space to gain different vantage points. However, the experience is sequential and linear, with a beginning, middle and end. An example of a fixed path animated three-dimensional image can be created with Quick-Time VR software as shown in Figure 11.

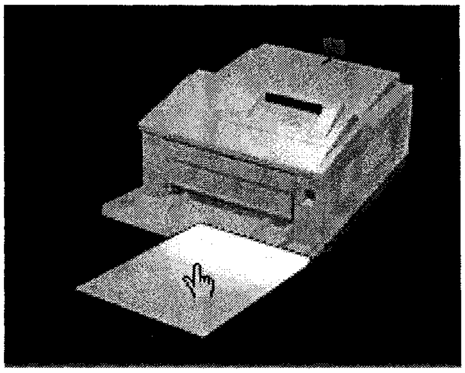

Figure 11: Centre for Design Research Printer Visualisation (QTVR).

Most Multimedia CD-ROM experiences are based around a number of pre-designed paths, created by the designer to direct the user to a desired understanding. In these instances there is a greater control from the user, who may even move around the information using hyperlinks, thereby taking a random path through a set number of nodes.

2.6.4 Key Attributes of Two, Three Dimensional Image and VR

In the context of this research, images as signs have been classified in order to analyse and identify their unique attributes. This classification enables the differences between a two-dimensional image, three-dimensional image, animation (linear and multiple path) and Virtual Reality to be distinguished. The aim of this classification has been to identify appropriate case studies, as well as define images for the communication models. A summary of this classification is illustrated in Table 4.

<table>
<tr><th>Image Type</th><th>Description</th><th>Movement</th><th>Interactivity</th></tr>
<tr><td>2D</td><td>Elevational Representation</td><td>Static</td><td>Un-interactive (Interactive at a pixel or frame level).</td></tr>
<tr><td>3D</td><td rowspan="4">Renaissance Perspective

(Monocular Depth Cues, Occlusion, Size Differences, Linear Perspective, Shading, Texture Gradients and Aerial Perspective.)</td><td>Static</td><td>Un-interactive (Interactive at a pixel or frame level).</td></tr>
<tr><td>Single path 3D Animation</td><td>Linear Time</td><td>Singular pre-determined interactive 'path'</td></tr>
<tr><td>Multiple path 3D Animation</td><td>Linear Time</td><td>Multiple Pre-determined Interactive 'paths' & Hypertext</td></tr>
<tr><td>3D Virtual Reality</td><td>Real Time & Linear Time</td><td>Linear Animation Combined with Real-time Animation</td></tr>
</table>

Table 4: Key Attributes of the Two and Three Dimensional Images.

User preference for different types of representation have been researched heavily in computer science. Card suggests that: "One of the popular debates in information visualisation circles is about 2D versus 3D presentations." [101] Some investigators therefore have questioned the appropriateness of the media for the context of use in particular work at LUTCHI Research Centre.[102] They base their work on studies by Stenning and Oberlander[103] which investigated the strengths of different representational systems for conveying the same problem, in particular the empirically proven advantages of graphical over linguistic representations. According to Card, traditionalists argue that: users are familiar with 2D paper presentations, that 2D presentations are simpler, occlusion is reduced, and computer speeds are faster. In contrast, promoters of 3D presentations

[101] Card, S. K., Mackinlay, J. D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.633.
[102] Williams, D. Multimedia, Mental Models and Complex Tasks, LUTCHI Research Centre, Department of Computer Studies, Loughborough University, *CHI96 Conference Companion*, 1996, p.65.

suggest that the real world is three dimensional and usability is increased as more space is available on the screen to display complexity.[104] However, Sherman notes that: "preference varies depending on who is using the application" and that the best option is to define the user, or guide users' expectation through the use of genre.[105] Similarly, considerable research is investigating HCI using related fields of psychology, computer science and human factors, often focusing on scientific methods of investigation. Many of these research projects focus on individual aspects of the interface regardless of their effect when combined with other media. In contrast, this research uses a design approach which is more holistic (see Section 2.8 for further discussion).

[103] Stenning, K. & Oberlander, J. A Cognitive Theory of Graphical and Linguistic Reasoning: Logic and Implementation. *Cognitive Science*, 19(1), 1995, p.97-140.
[104] Card, S. K., Mackinlay, J. D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.633.
[105] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.427.

2.7 Design Issues

The key issues faced by a designer using VR include ideological issues involving choice of signs (2D/3D/text), metaphor, level of narrative or control (linearity within the system) navigability, genre, use of sound and haptics. Additionally, designers face a range of other factors including financial determinism, technological determinism and professional determinism. It will be shown that these factors both define and constrain current practice in three-dimensional GUI. From the issues presented in this chapter a range of questions have been developed for interrogating the selected case studies during the semi-structured interviews. These questions cover issues of metaphor, navigation, mental models, sound and narrative. A complete set of interview questions can be found in Appendix 2.

2.7.1 Use of Metaphor

All virtual worlds use metaphor in one form or another to convey concepts to users. Metaphors are critical tools for communicating, allowing users to maximise their effectiveness in utilising GUI, as noted by Marcus: "Good metaphors enable users to comprehend, use and remember information more quickly, with greater ease, and with deeper satisfaction by effectively managing the user's expectation, surprise, comprehension, and delight."[106] The metaphor allows users to consider the information presented in terms they understand. As Fiske notes, we employ metaphor, to "transpose qualities from one plane of reality to another."[107] As Lakoff suggests: "New metaphors are capable of creating new understandings and, therefore, new realities."[108] In this respect Erickson suggests that metaphors act as 'cognitive hooks'.[109] An example here might be the use of monetary representations for time, as in 'wasting' time and 'running out of' time, when of course time does not actually possess such attributes.[110] These metaphors have been used in the language of our western society for so long that they are accepted as truisms - assumptions that are made each day. Thus, it is often the case that individuals are unaware of the organisational representations, metaphors, or mental models they use to make sense of the world.[111]

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[106] Marcus, A. Metaphor Design in User Interfaces: How to Manage Expectation, Surprise, Comprehension, and Delight Effectively. *CHI 97 Conference Proceedings*, 22-27 March, 1997, p.173.
[107] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.95.
[108] Lakoff, G. & Johnson, M. *Metaphors We Live By.* The University of Chicago Press, 1980, p.235.
[109] Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.128.
[110] Lakoff, G. & Johnson, M. *Metaphors We Live By.* The University of Chicago Press, 1980, p.7-8.
[111] Preece, J. et al. *Human-Computer Interaction.* Addison-Wesley Longman Ltd., 1994, p.147.

The application of metaphor to technology makes sense of novel applications of technology in terms of older technologies or experiences. As Fiske highlights: "Metaphor exploits simultaneous similarity and difference."[112] In this way, metaphors present new information in terms of old ideas. An early example can be found in the 'horseless carriage', which moved as fast as a horse and was considered an expensive novelty. The term clearly had its limitations in describing the motorcar, but operated acceptably as a metaphor.[113]

In computing, iconic metaphors were developed at Xerox PARC by Norman Cox[114] and Alan Kay.[115] Kay used an understanding of the work of the psychologists Bruner and Piaget to develop new design methodologies. Bruner had identified three key learning mentalities; the enactive, iconic and symbolic.[116] The enactive, was considered to be the foundation learning mode, a base level of learning where: "Our understanding of the world is fundamentally linked to visual stimulation and the tactile experience of manipulating objects in our environment."[117] In contrast, the Iconic stage was dominated by the visual, as demonstrated by classic psychological tests on children involving recognition of similar volumes of liquids in different shaped containers. This iconic stage is closely associated with the previous enactive stage. As such, when users experienced a new concept, for example the introduction of a new graphic on an interface, they measured it in relation to concrete 'enactive' experiences. As Athavankar suggests: "It is significant that the decision on this [sign's] positioning is primarily on the basis of the visual information associated with concrete objects."[118] An example of an iconic VR metaphor can be seen in IBM's RealPlaces, a three-dimensional version of the desktop metaphor in the form of an office environment.[119]

On PCs the now familiar 'desktop metaphor' uses office iconography to convey ideas about the computer's functionality. Yet this is not the only metaphor in place, with

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[112] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.92.
[113] Pimentel, K. & Teixeira, K. *Virtual Reality: Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.9.
[114] Lynch, P. Visual Design for the User Interface, Part 1: Design Fundamentals. Yale Centre for Advanced Instructional Media. *Journal of Biocommunications,* 21(1), 1994. p.23.
[115] Kay, A. User Interface a Personal View. In: Laurel, B. (ed.) *The Art of Human-Computer Interface Design.* Addison-Wesley Publishing Company, 1989. p191.
[116] Bruner, J. S. *Toward a Theory of Instruction*, Belknap Press, 1974, p.18.
[117] Kay, A. User Interface a Personal View. In: Laurel, B. (ed.) *The Art of Human-Computer Interface Design.* Addison-Wesley Publishing Company, 1989, p.191-209.
[118] Athavankar, U. Categorisation Natural Language and Design. *Design Issues,* 5(2), Spring 1989, p.104.

computers also employing, amongst others, the 'window' metaphor, and the 'scrolling' metaphor to organise and move through data. The number of different metaphors involved in the GUI require computer users to deal with different mental models in a single computer environment. Surprisingly, these 'composite metaphors'[120] seem to pose few problems for users, as Preece notes: "From a cognitive perspective, it might be assumed that people would have difficulties with interpreting composite metaphors. In most instances though, it seems that people can readily assimilate differing concepts and develop multiple mental models."[121]

2.7.1.1 Limitations of the Metaphor

Metaphors have the capacity to constrain concepts and classic confusion in meaning can occur, as with the Apple trash can, both deleting work and retrieving your disk from the system. This can be problematic because the power of a term, once accepted by a culture, affects how that object is perceived by the culture. Thus, in emancipating users from command prompt-based DOS, the 'desktop metaphor' paradoxically also constrains users by presenting many of the *problems* of the old workspace in the new interface. As Laurel notes, "Interface metaphors have limited usefulness. What you gain now you may have to pay for later."[122] This makes it difficult to improve beyond the boundaries of the metaphor. This may be explained from a psychological perspective, as Athavankar suggests that in our creation of categories the sign which is considered to be 'typical' is based mainly on numerical strength rather than concepts of good or bad.[123] It would seem that the system that is most powerful in setting the metaphor is the one we see most often. Levi-Strauss sees the logic of using metaphors as 'the logic of the concrete.'[124] This may provide additional insight into why 'real' world representations are so prolific in the HCI environment, as they are clearly seen 'most often'. Thus, daily experience provides the user valuable feedback and confirmation of the system. The association between the real world and representation is clearly evident in many GUIs, where the notion of Mimesis[125] has been ascribed to the heavily reflective nature of the interface appearance.

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119 Roberts, D. RealPlaces, 3D Interfaces of Office Applications. *The 3D Interface for the Information Worker,* IEE London, May 19, 1998, p.2/1.
120 Carroll, J., Mack, R., & Kellogg, W. Interface Metaphors and User Interface Design. In: Helander, M (ed.) *Handbook of Human-Computer Interaction*, North-Holland, 1993. pp. 67-85.
121 Preece, J. et al. *Human-Computer Interaction*. Addison-Wesley Longman Ltd., 1994, p.147.
122 Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.131.
123 Athavankar, U. Categorisation Natural Language and Design. *Design Issues,* 5(2), Spring 1989, p.104.
124 Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.117.
125 Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.45.

2.7.2 Realism versus Abstraction Debate

The potential uses of the VR are diverse (see Section 2.3.2), but there are essentially two aesthetic extremes in current VR development, namely modelling the real world and abstract symbolic visualisation as illustrated by Figure 12. This section looks at the debates and issues raised by this aesthetic dichotomy.

Mimetic	**Abstract**
Iconic	Symbolic
Real world referents	Hyper-geographic
Simulation	Visualisation

Figure 12: The Iconic and Symbolic Interface.

2.7.2.1 Realism

At the iconic end of the spectrum of GUI many designers seem intent on creating the *most* 'real' representation. As Krueger notes: "The ultimate interface between the computer and people would be to the human body and human sense." Manovich describes this desire for realism as 'illusionism'.

> "...Illusionism in computer animation refers to the simulation of perceptual properties of real-life objects and environments (shape, shading, texture, atmospheric effects) as seen through the simulated codes of traditional cinematography (composition, lighting, choice of lens and camera movement)."[126]

By definition Virtual Reality uses the concept of 'reality' as a metaphoric vehicle to define the technological possibilities of the virtual. Virtual — having the effect but not the actual form of what is specified. Reality — the fact, state or quality of being real or genuine. As

[126] Manovich, L. "Real" Wars: Esthetics and Professionalism in Computer Animation. *Design Issues,* 8(1), Fall 1991, p.18.

such, the term Virtual Reality has been termed both an oxymoron and a pleonasm due to the contradictions and redundancy inherent in the use of the expression.[127] It is not surprising that this form of representation is most commonly associated with VR. In fact the Oxford English Dictionary definition of Virtual Reality refers singularly to this genre as noted in the following definition: "Virtual Reality. n. *Computing* a system in which images that look like real objects are created by computer and can be interacted with by using special electronic equipment."[128] As such, realism is a form of VR that is so widespread it is often seen as the defining aesthetic. Realism seems most appropriate where the goal of the communication is descriptive, as with the widespread use of VR in architectural simulation. Here, users are able to 'walk through' spaces. This genre is described by Sherman as the 'Location Walkabout,'[129] where companies like Insite Virtual Reality Consultants in Newcastle, UK, use VR software to visualise designs for planning purposes.[130] In another example of realism, Art+Com, from Berlin, was commissioned by Daimler-Benz AG to develop a VR-System for marketing support of the A-class Mercedes. Here users could select the different trim and colour combinations they desired for their car and visualise the design iterations in real time. In this instance it was important that what users saw represented what they could purchase.[131]

A further clarification is that realism is often misinterpreted for meaning a 'perfect' representation, in detail and without flaws. Clearly this is a utopian vision which only exists in TV adverts and other media and is in itself un-naturalistic. Linked to this, a more subtle influence on Realism has emerged from a form of professional determinism. Here the key issue is the differentiation between images that have been produced by professional designers and those created by hobbyists or amateurs. Manovich suggests two key aesthetic choices that are affected by designers' desire for expressing their professionalism: smoothness and complexity.[132] In this sense the differentiation between the amateur and the professional is by technical standards, which in themselves are closely aligned to the financial expenditure on equipment or software.

[127] Negroponte, N. *Being Digital.* Hodder and Stoughton, 1995, p.116.
[128] Fowler, F. G., & Fowler, H. W. (eds.) *Pocket Oxford English Dictionary.* 9th ed. Oxford University Press, 2002, p.1031.
[129] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003. p.59.
[130] Insite, designs are predominantly architectural, enabling clients to 'walk through' building concepts before they are realised.
[131] Results were presented by Daimler-Benz at the IAA motor show in Frankfurt, September, 1997.
[132] Manovich, L. "Real" Wars: Esthetics and Professionalism in Computer Animation. *Design Issues,* 8(1), Fall 1991, p.21.

However, visual realism or illusionism is not necessarily the only goal of computer animators. For example, studies have shown that latency (the speed of update of the image after movement) is an important element of the believability of the space, in preference to realistic imagery.[133] As Langham notes:

> "...the 'realism' of virtual reality systems is not a product of how well they mirror the "real" world, but rather the extent to which they create structures that allow for a sense of a routinised existence, a sense of fixity we generally associate with ordinary, repeated, commonplace behaviour."[134]

And, although all graphical representations will lie somewhere on a realism continuum, realism alone does not necessarily result in *better* communication.

McCloud suggests that the more abstract an image becomes, the more it is able to represent concepts generically and that this 'universality' is the art of cartoons.[135] As also noted by Frutiger: "Generalisation results in simpler forms, because they contain less visual information, are easier to process, recognise and react to."[136] Universality describes the ability of an individual sign to represent a class of artefacts at higher-level groupings. This generality allows them to be interpreted as representative of a broader class, as shown in Figure 13, with the face on the right representing all faces.

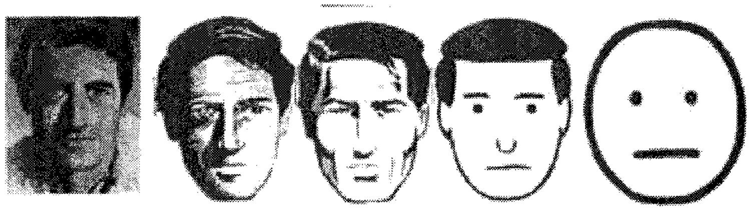

Figure 13: McCloud's abstraction continuum.

2.7.2.2 *Abstraction*

Beyond iconic interfaces, significant discussions have taken place about the potential of novel interface metaphors and interaction. Such interfaces have been described as hyper-

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[133] Preece, J. et al. *Human-Computer Interaction.* Addison-Wesley Longman Ltd., 1994, p.336.
[134] Langham, D. The Common Place MOO: Orality and Literacy in Virtual Reality. *Computer-Mediated Communication Magazine,* 1(3), July 1994, p.7.
[135] McCloud, S. *Understanding Comics.* Perennial, 1994, p.31.
[136] Frutiger, A. *Signs and Symbols: Their Design and Meaning.* Studio Editions, 1989, p.179.

geographic,[137] envisioning,[138] simulation of complexity (SOC),[139] post-symbolic communication,[140] "magical" worlds,[141] conceptual representations,[142] or post-geographical interface.[143] These concepts of worlds beyond reality are as old as the idea of VR, as Myron Kruger described in his 1970s research:

> "The responsive environment has been presented as the basis for a new aesthetic medium based on real-time interaction between men and machines. In the long range it augurs a new realm of human experience, artificial realities which seek not to simulate the physical world but to define arbitrary, abstract and otherwise impossible relationships between action and result."[144]

Peter Cochrane suggests we know a lot about iconic interfaces, as he notes: "For over 15 years icons have become well established as a means of navigating computer environments. But they are flat, static, and only able to convey limited information."[145] How they work and what their benefits are has been studied, yet beyond this there are other examples where designers have attempted to move away from real-world referents for their virtual representations.[146] These are non-iconic interface model systems using Euclidean geometry and symbolic interface and are widely thought to be opening up new areas of knowledge, for example scientific observation. Such areas of new knowledge are moving beyond the *déjà vu* of the real world iconic metaphor. As Michael Heim notes, "Virtual worlds evoke imagination only if they do not simply reproduce the existential features of reality but transform them beyond immediate recognition."[147] Peter Cochrane refers to such space opportunities as hyper-geographic:

> "When we move to the world of the bit, we encounter a new geography of multiple dimensions. This world is a networked n-dimensional space of multiple copies,

[137] Cochrane, P. *108 Tips for Time Travellers.* Orion Business Paperbacks, 1997, p.60.
[138] Preece, J. et al. *Human-Computer Interaction.* Addison-Wesley Longman Ltd., 1994, p.152.
[139] Mallen, G. Back to the Cave: Cultural Perspectives on VR. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.268.
[140] Lanier interview in Heilbrun, 1989.
[141] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003. p.212.
[142] Ganter, J. H. Comparison of Representations for Complex Earth Volumes. In: Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.216.
[143] Hillis, K. *Digital Sensations: Space, Identity, and Embodiment in Virtual Reality.* University of Minnesota Press, 1999, p.133.
[144] Krueger, M. Responsive Environments. In Packer, R. & Jordan, K. (eds.) *Multimedia: From Wagner to Virtual Reality.* W.W. Norton & Company Ltd., 2001, p.119
[145] Cochrane, P. *108 Tips for Time Travellers.* Orion Business Paperbacks, 1997, p.60.
[146] BT Projects including Information Gardens, visualisation of telephone usage in three dimensions, Call Waiting, Emotional Icons and Smart Desk Concept 2010.
[147] Heim, M. *The Metaphysics of Virtual Reality.* Oxford University Press, 1993, p.136.

existence, connectivity, locations and forms. Our concepts of physical geography do not easily translate in this new hyper-geographic world."[148]

Here computers offer new opportunities to visualise complex systems and may impact on all spheres of science from astronomy to fluid dynamics. One example is that of Warren Robinett who at the University of North Carolina has developed a system that allows users to 'fly through' protein molecules.[149] These forms of simulation have a significant role in VR development as Loeffler suggests: "Scientific visualisation has been one of the most important driving motives in the development of virtual worlds technology."[150] As Kevin Robbins also highlights:

> "New dimensions of reality are opened up to the powers of observation. With computer graphics workstations, it becomes possible to 'see' things that are otherwise inaccessible to the human gaze...It is now actually possible 'to visualise the interior of a dying star or a nuclear explosion. The mind can go places where no physical being will ever be likely to go'."[151]

Such interfaces might be considered artificial metaphors[152] as they have metaphoric associations on at least one level, yet are embodied in an arbitrary symbolic form. Lanier uses the term post-symbolic to describe a slightly different interface, involving a bodily interaction, in preference to visual communication.

Hillis has concerns that the post-geographic interfaces are unstable metaphors of space. However, all metaphors and representations gain their meaning by association in the mind of the reader, or they become meaningless. As Lakoff notes: "In actuality we feel that no metaphor can ever be comprehended or even adequately represented independently of its experiential basis."[153] If this were not the case, the question would remain, how to represent something that has never been presented? Mallen notes that apart from pie charts, bar graphs, and so on, there is no commonly accepted visual vocabulary for displaying complex processes and suggests that the engineer or designer has to create a visual vocabulary to do this as he notes: "This is an imaginative and, of course, an aesthetic act which emphasises that the creative process of understanding the world and the creative process of visualising that understanding are inseparable. At this level science and art are

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[148] Cochrane, P. *108 Tips for Time Travellers.* Orion Business Paperbacks, 1997, p.155.
[149] Loeffler, C. and Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.xx.
[150] Loeffler, C. and Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.256.
[151] Robins, K. *Into the Image: Culture and Politics in the field of Vision.* Routledge, 1996, p.155.
[152] Barfield, L *The User Interface: Concepts and Design.* Addison-Wesley, 1993.
[153] Lakoff, G. & Johnson, M. *Metaphors We Live By.* The University of Chicago Press, 1980, p.19.

one."[154] Ganter discusses conceptualised representations (C-Reps) in contrast to physical representations (P-Reps).[155] Similarly, Mallen describes the distinction between the iconic and symbolic as two ways of knowing, the simulation of reality (SOR), and the simulation of complexity (SOC). In a discussion on VR he notes that the simulation of reality paradigm follows from a traditional world-view of the individual, with the second paradigm seeing the knower as an audience of reality where: "In this role the computer graphics screen is a tool, like the telescope or microscope, only it allows the presentation of the unseeable, the very large and the very small and the complexity in between."[156] In contrast, Preece suggests that interfaces that bring to life abstract ideas are a form of envisioning.[157] These two paradigms map onto VR in terms of realism (simulation) on the one hand and abstraction (visualisation) on the other.

Nelson suggests a further distinction with his description of 'virtuality'. Here the design is not driven by likeness, as a metaphor operates, but rather by 'conceptual structure and feel'. Additionally he suggests that these elements are understood and implemented already when things lack real world counterparts. An example might be wormholes, which present unreal time space concepts.[158] Heim meanwhile refers to unrealistic interfaces as 'irrealism' preferring to use the concept of transmogrification (i.e. transmogrify – to change into a different shape or form, especially that is fantastic or bizarre.)[159] to describe the quality of change.

Clearly, given the infancy of the subject, the terminology is far from settled, but there are essentially two extremes in current VR development, namely modelling the real world and abstract symbolic visualisation as illustrated by Figure 12. Along this continuum there is a significant number of genres from cartoon to location walkabout. It follows that the same meaning can be portrayed at different points along the continuum, although it will be affected by its presentation and medium. The next section will look briefly at these genres and their implications for usability and design.

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[154] Mallen, G. Back to the Cave: Cultural Perspectives on VR. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.268.
[155] Ganter, J. H. Comparison of Representations for Complex Earth Volumes. In: Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.216.
[156] Mallen, G. Back to the Cave: Cultural Perspectives on VR. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems.* Academic Press Limited, 1993, p.268.
[157] Preece, J. et al. *Human-Computer Interaction.* Addison-Wesley Longman Ltd., 1994, p.152.
[158] Nelson, T. The Right way to Think about Software Design. In: Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.132.
[159] Heim, M. *Transmogrification* [Online]. 1999, p.2. URL: www.mheim.com. [June 2004].

2.7.3 The Language of VR

The language of VR is essentially its organising principles, the elements that bind a structure together and make sense of seemingly unrelated things. Saussure describes language as a system of relationships, where the meaning of the term 'river' is derived from its relationship to, in particular its difference from, the concept of a 'stream' or a 'dyke'. Athavankar, looks at this process of mental categorisation in language and products confirming that: "...the human brain offers a seemingly unlimited capacity to store symbols for objects and events of the environment." [160] However, he explains that "the need for effective retrieval from this vast storehouse of information has prompted humans to develop a storage strategy based on semantic coding and organisation of input information." [161] Virtual Reality as a language is made up of signs, symbols and syntax that are combined to present a message to the user. This language is formed either consciously or unselfconsciously by the interface designer and evolves through shared use with the participants of the VR experience. As noted by Frutiger, "communicability of a representation depends on a shared context between sender and receiver that allows signs to be interpreted within a pragmatics comparable to the one under which they were encoded."[162] This is important, or what might result otherwise is a form of exclusivity, a so-called 'semiotic elite', where only members of the same group can understand the specificity of the metaphor or sign.

Sherman takes the discussion further, suggesting six types of representational worlds or physics which can be applied to VR, namely: static world, cartoon world, Newtonian physics, Aristotelian physics, choreographed physics and other-world physics.[163] As noted by Pimentel: "Inside a virtual world, everything is potentially alive because the laws of reality are up to the designer. The computer can just as easily bring to life the world of atoms as it can let you fly through space."[164] Issues of space and time are important in VR, where they can be controlled as part of the overall design.

Within this, Sherman suggests classes of interaction styles (the forms) and narrative styles or genres. VR genres include the "shoot everything in sight" games, scientific

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[160] Athavankar, U. Categorisation Natural Language and Design. *Design Issues,* 5(2), Spring 1989, p.100.
[161] Athavankar, U. Categorisation Natural Language and Design. *Design Issues,* 5(2), Spring 1989, p.100.
[162] Frutiger, A. *Signs and Symbols: Their Design and Meaning.* Studio Editions, 1989, p.188.
[163] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.399.
[164] Pimentel, K., & Teixeira, K. *Virtual Reality: Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.xxi.

visualisation, manufacturing procedure analysis, training, historic site recreation, prototyping, multi-presence and CSCW (see Section 2.3.2 for a list of applications of VR).

Yet the development of VR as a language is immature, and as such literacy amongst users is limited, as noted by Sherman: "This language is very young and immature, and is evolving with each new experience. Many of the elements in the current language of VR are similar to their roots in other related media, and need to be adapted to a more suitable idiom."[165] This is echoed by Pimentel and Teixeira: "Virtual Reality, however, will bring about the need for a new kind of literacy, one that's behaviourally as well as cognitively based. When designers construct a world, they'll be forced to consider the actions they are taking the user through."[166]

The development of new metaphors and new visualisations is not straightforward, as Card notes: "The stock of visualisations is still not large and they are not easy to invent. We feel there are still a number of important visualisations waiting to be discovered."[167] Any new genre would have to go through a process of conventionalisation, where conventionalisation is: "The common cultural process by which innovative, unconventional codes gradually become adopted by the majority and thus become conventional."[168] Yet this does not mean that the past determines the future, rather it provides a means to identify, judge and understand new experiences. Athavankar suggests that in addition to seeking order, we also actively seek change: "The human mind works to balance two contradicting requirements. It seeks deviations that interest but also simultaneously searches for belongingness."[169] This is also noted by Crozier, who, in a discussion on familiarity, cites Berlyne's prediction "that people will most like objects and places that are moderately familiar and will be more averse to the novel and the over-familiar."[170] Too much change can challenge our existing constructs of thought, causing us to rely more heavily on the predictable unchanging aspects of our world to support new experiences.

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[165] Sherman, W. R., & Craig, A. B., Literacy in Virtual Reality: A New Medium. *Computer Graphics,* 29(4) ACM Press, Nov. 1995, p.6.
[166] Pimentel, K., & Teixeira, K. *Virtual Reality: Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.353.
[167] Card, S.K., Mackinlay, J.D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.640.
[168] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.81.
[169] Athavankar, U. Categorisation Natural Language and Design. *Design Issues,* 5(2), Spring 1989, p.108.
[170] Crozier, R. *Manufactured Pleasures: Psychological Responses to Design.* Manchester University, 1994, p.66.

2.7.4 Interaction: Narrative, Navigation and Kinesthetics

One key characteristic of virtual environments is the capability for the user to have significant control over their experience. Not only can they choose non-linear paths through the information displayed to them, but they are co-producers of the experience. This raises issues of authorship, where the user has authorship of the experience but not the content, Sherman terms this 'creatorship.'[171] In this sense the user moves from being a passive consumer of messages to being an active 'prosumer'[172] of meaning. It is however through narrative that users are able to make sense of the experience, get a sense of 'closure' and in particular, know when it is over (denouement). VR can involve a number of forms of narrative, namely: undirected narrative, directed (or plot-based) narrative and flexible narrative.[173] It may be that users are directed, as with reading a book, or task orientated, as with printing a document. Virtual worlds have the capability of portraying both of these, however the designer should be clear on what is called for.

The kind of narrative is likely to indicate how to treat the navigational aspects of the interface. Within a particular visual genre, the chosen systems of navigation within virtual worlds are fundamental anchors of meaning, supporting or contradicting the overall theme. This 'behavioural space' refers to the way that users are able to move in space. 'Real-time fly through' commonly refers to systems where the user has control over the path they can take through the world. Trumbo notes the importance of the design of icons and directional graphics as well as the access and level of interactivity as key design considerations.[174] In particular, on the role of mental models he remarks: "We rely on spatial memory to create mental maps that allow us to repeat an action or to retrace our steps. The constraints of short- and long-term memory are important concerns for the multimedia designer."[175] Examples of mapping systems include creating a small scale version of the world, known as a world in miniature (WIM), or the generation of real time plan views of the virtual environment.[176] Additionally, landmarks, flying carpets,

[171] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.50.
[172] Toffler, A. *The Third Wave*. Bantam Books, 1989, p.266.
[173] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.75.
[174] Trumbo, J. The Spatial Environment in Multimedia Design: Physical, Conceptual, Perceptual and Behavioural Aspects of Design Space. *Design Issues,* 13(3), Autumn 1997, p.28.
[175] Trumbo, J. The Spatial Environment in Multimedia Design: Physical, Conceptual, Perceptual and Behavioural Aspects of Design Space. *Design Issues,* 13(3), Autumn 1997, p.26.
[176] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.323.

crumbs[177] and virtual CAIRNS[178] (A trail of virtual pebbles) are just some of the methods that have been employed to allow users to track progress through a virtual space. Without set paths or navigational cues, users can quickly become confused in VEs. Trumbo continues: "The designer's challenge is to use directional and non-directional space to create multiple paths through a coherent, navigable garden of content rather than a labyrinth of dark, empty passageways and blind alleys."[179]

[177] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.229.
[178] Platt, P. and Willard, A. The Ramblers Guide to Virtual Environments. *The 3D Interface for the Information Worker,* IEE London, May 19, 1998, p.3/1.
[179] Trumbo, J. The Spatial Environment in Multimedia Design: Physical, Conceptual, Perceptual and Behavioural Aspects of Design Space. *Design Issues,* 13(3), Autumn 1997, p.23.

2.8 What does Design have to Offer to this Field?

Computer scientists and artists have explored the potential of VR with significant research projects to date, yet from very different perspectives and with different goals as Sherman notes:

> "The advance of a medium is often made by two forces that approach it from two different viewpoints. These are the artistic viewpoint, and the engineering viewpoint. The technologists (engineers) often provide the basis for the medium (the carrier technology), and push to improve the bandwidth and flexibility of what can be done in the medium. The artists see a new medium as a new way to express their ideas, or simply as a place to explore the representation of ideas, thus pushing the content of the medium, and making it more interesting to an audience."[180]

However, there is little evidence of academic design research in this field. Design Research into three-dimensionality and VR to date has focused on the process of designing using computers as tools. In particular, research into multimedia authoring[181] and CAD[182] at the University of Northumbria has investigated the use of digital media in the design process. Students at Art Centre College of Design in Pasadena, have been experimenting with avatar representation in virtual worlds under the direction of Michael Heim.[183] However, currently there are few other examples of industrial academic research into the design of virtual worlds from a designer's perspective.

Practicing designers are working using VR particularly in the games and automotive industries, but their methods are not widespread or academically validated. Commercial research into VR by designers is taking place at research labs such as Media Lab Europe,[184] BT and IBM yet this is usually led by a computer science or human factors perspective.[185] In Germany, Art + Com have an established business delivering VR solutions to clients applying an interdisciplinary approach concerned with the integration

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180 Sherman, W. R., & Craig, A. B., Literacy in Virtual Reality: A New Medium. *Computer Graphics,* 29(4) ACM Press, Nov. 1995, p.5.

181 Misera, T. Industrial Designers, the New Craftsmen of Media? *Multiviewpoint: Shaping the Human Computer Interface*, Design Research Society Conference, Centre for Design Research, Newcastle, July 02, 1998. [unpublished].

182 Warburton, N. A Heuristic Model for Digitally Integrated Design. *Co-Design*: s3.07. 04:05:06. 96: 2

183 Heim, M. *Transmogrification* [Online]. 1999, URL: www.mheim.com. [June 2004]

184 McDarby G. *Mindgames.* Media Lab Europe, Dublin. URL: http://mindgames.medialabeurope.org. [May 2004].

185 Penndorf, W. Representing Reality: Virtual Reality in Automobile Manufacture. *Multiviewpoint: Shaping the Human Computer Interface.* Design Research Society Conference, Centre for Design Research, Newcastle, July 02, 1998. [unpublished].

of computer technology, communication and design using VR for 'virtual product presentation'.[186]

Design methods have a lot to offer and to gain from understanding how the process of designing might be applied to emergent fields such as VR and three dimensional visualisation. As McCoy notes: "Nothing pulls you into the territory between art and science quite as quickly as design. It is the borderline where contradictions and tensions exist between the quantifiable and the poetic. It is the field between desire and necessity."[187] This bridging of art and science is often considered to be the domestication of technology, when designers bring technology to bear on users' needs. As Pantzar suggests: "Television, radio, movies, and recordings have witnessed a metamorphosis: from toy, through mirror, and towards art."[188] Virtual reality appears to have moved through these phases of integration, as has television and all other forms of cultural technologies. As Brenda Laurel cites: "Movies did not flourish until the engineers lost control to artists - or more precisely, to the communications craftsmen. The same thing is happening now with personal computers."[189] Therefore, the way this medium develops depends very much upon the designer's chosen approach to the design of its form, and thus its capabilities.

2.8.1 Function and VR

Designers understand the link between function and aesthetics, derived from early debates centred on the axiom 'form follows function'. The mechanistic and functional aspects of designed things are seen to determine their shape. In VR, objects act as signifiers - this is their visual function as opposed to any practical function. As Heim notes on a VR project at Art Centre: "The schoolroom contains wooden chairs and desks typical of the banal furniture of many conventional classrooms... these accoutrements serve no functional purpose in the virtual world as the avatar cannot – and need not – assume the seated position."[190] In addition to problem solving, designing is about a visual acuity, sensitivity and visual literacy. In VR, objects can have 'expressive levels' made up of the objects'

[186] Art+Com. URL: www.artcom.de. [May 2004].
[187] McCoy. *High Ground Design.* URL: www.highgrounddesign.com/mccoy/cran3.htm. [June 2004].
[188] Pantzar, M. Domestication of Everyday Life Technology: Dynamic Views on the Social Histories of Artifacts. *Design Issues,* 13(3), Autumn 1997, p.53.
[189] Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.xi.
[190] Heim, M. *Transmogrification* [Online]. 1999, p.4. URL: www.mheim.com. [June 2004].

basic shape, surface, implied materials, tactile characteristics and perceptual presence. In this respect the potential for VR as a meaning making medium presents lots of opportunities for designers to experiment within a novel interface.

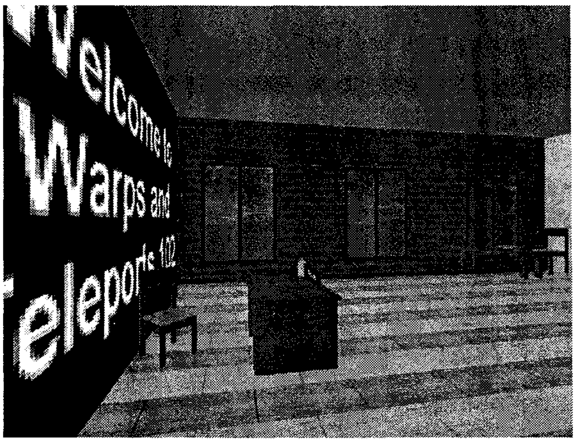

Figure 14: Room Developed at Art Centre (from www.mheim.com).

Broadly speaking design has moved away from modernist, functional view of form to one based on users, anthropology and meaning (brand). These issues have relevance for designing sophisticated multimedia and VR experiences. Research at the Royal College of Art (Dunne and Raby) and at Interaction Design Institute Ivrea (Crampton-Smith) into novel interfaces, poses interesting questions about the role of technology in society, as this is perhaps the closest to fine art that industrial products have ever been.[191] This move has been from high-tech to 'high-touch',[192] where high-touch designers are no longer making a lamp, for example, purely for decoration, but instead are changing the *idea* of a lamp.

[191] Dunne, T. & Raby, F. [Online]. URL: www.dunneandraby.co.uk/ [June 2004].
[192] Janjigian, R. *High Touch: The New Materialism in Design.* Columbus Books, 1987, p.2.

2.8.2 Relevant Debates in Product Design

Some of the prevailing debates in product design research and practice have relevance for VR development, in particular the concept of 'product semantics'[193] in the late 1980s, 'experience design'[194] in the mid 90s and more recently the 'meta product'.[195]

In three dimensional industrial design, product semantics refers to the way the shape of a product can convey meaning. Work at Philips and Cranbrook in the 1990s led the way with research into the way three dimensional form acted as metaphor. Likewise Smets[196] work looked at products as carriers of sensorial meaning. Similarly, Durrell Bishop's work at the RCA's Computer Related Design Studio was novel in its application of form to intangible concepts, such as the project that depicted an answering machine that used small marbles as pointers for a kind of tangible message (see Figure 15).

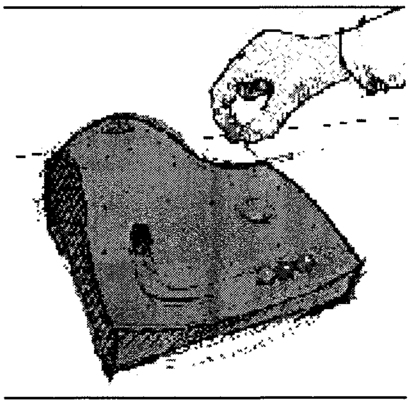

Figure 15: Durrell Bishop's Answer Machine.

Naisbitt discussed the human reaction to increasing levels of technology: "Whenever new technology is introduced into society, there must be a counterbalancing human response - that is, high-touch. The more high-tech, the more high-touch."[197] This premise has formed the basis of the 'experience economy',[198] where designs are no longer seen as being

[193] Aldersey-Williams, H. et al. *The New Cranbrook Design Discourse.* Rizzoli International Publications. 1990, p.16.
[194] Perkins, S. *Experience: Challenging Visual Indifference through New Sensory Experience.* Booth-Clibborn, 1995.
[195] Powell, D. *Product Design* [Online]. Design Council Online Resource, 2004, URL: www.designcouncil.org.uk/design. [June 2004].
[196] Smets, G. et al. Form Giving: Expressing the Nonobvious. *Conference Companion on Human factors in Computing Systems.* April 1994.
[197] Naisbitt, J. *Megatrends: Ten New Directions Transforming Our Lives,* Warner Books, 1982.
[198] Pine II, B. J, & Gilmore, J. H. *The Experience Economy.* Harvard Business School Press, 1999, p.4.

functionally driven. As Bauman notes: "Consumers are first and foremost gatherers of sensations; they are collectors of things only in a secondary and derivative sense."[199] The new design mantras expressed by designers at Alessi in Italy, IDEO in America and Frog design in Germany include 'form follows fiction', 'form follows fun' and 'form follows fashion'. Thus in the post-modern, experience society, designs are no longer seen as being technological achievements, but rather as eclectic generators of ritual or sensation, even ambiguity and contradiction.[200]

Simultaneously, the remit of the designer has broadened to what might be described as the 'meta-product' as noted by Powell:

> "Advancing technology, allied to extremely complex operational software and capability, are blurring the boundaries of what we understand by 'product'. Sometimes, the hardware we hold in our hand, or with which we interact, is just a small part of 'the product'. The activity of product design will continue to make inroads into the non-physical aspects of the product and even the 'virtual product' or meta product."[201]

Experience design refers to a type of designing which is based on a holistic, multidisciplinary, approach to the problem based on insight into users and their values, as noted by Ardill: "This experiential value can be delivered in many different forms - entertainment, education, enlightenment or even escapism - but all will be underpinned by a deep insight into our fundamental human needs, hopes, fears and aspirations."[202] Designers are therefore well placed philosophically and practically to add value to discussions about the content of VR worlds.

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[199] Bauman, Z. *Globalisation: The Human Consequences.* Polity Press, 2000, p.83.
[200] Young, R., et al. Beyond the Bauhaus: Redefining Design Education. ICSID Congress, *Exploring Emerging Design Paradigm, Oullim*, Seoul, Korea, 2001.
[201] Powell, D. *Product Design* [Online]. Design Council Online Resource, 2004, URL: www.designcouncil.org.uk/design. [June 2004].
[202] Ardill, R. *Experience Design* [Online]. Design Council Online Resource, 2004, URL: www.designcouncil.org.uk/design. [June 2004].

2.9 Conclusions from the Literature Review

From the literature review, the following issues underlined the relevance and novelty of the research. They can be grouped into key drivers and consequential opportunities. They demonstrate the gap in the literature that this research attempts to address.

Key Drivers:

- The effect of determinism on design practice (technological, financial and professional)
- The wide availability of signs and their implications for design decision making
- Designer's reluctance to use theory when designing.

Identification of Opportunities for Research:

- Lack of a holistic approach to considering image, in particular the relationship of different signs and their virtues and constraints
- Lack of a contextualised language of description for designers (Taxonomy)
- The potential for designers to contribute to the development of VR.

With VR, the important role that designers play in creating the 'rules' and framework should not be left to technological determinism alone. From this research the development of an overriding strategy to identify trends in empirical practice will also reveal opportunities that are not being exploited. In this sense some of the current examples of practice are too deterministic and narrowly defined rather than being holistic and integrated.

The computer is capable of transmitting a range of signs from two dimensional images to animation. The designer has at their disposal a range of media with which to re-present an idea or experience. This increase in choice presents a number of challenges, as McCoy notes: "Communications designers must selectively match media to the requirements of each communication problem's message, audience and context."[203] This poses a number of problems for the interface designer who must combine the most appropriate signs for the purpose being expressed. Differences can be identified between 2D images, 2D perspective images, animation and Virtual Reality. As Loeffler notes:

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[203] McCoy, K. Media, Culture and Technology, *Graphics Discourse PIRA/RSA Lecture.* London, April 15, 1994.

> "In computer interfaces, VR provides a qualitative leap beyond the two-dimensional graphical user interfaces popularised by Macintosh and Windows, just as those represent a qualitative leap beyond the one-dimensional command-line prompt of DOS, Unix and other early systems."[204]

The question remains whether different experiences will lend themselves to be communicated in a particular medium, such as the poetic use of words or the power of image in television. If there are generic virtues of different media, what are they?

With specific reference to VR, examples of practice are generally grouped together regardless of their content. In contrast, this research explores the possibility of classifying VR to see if within the medium, interfaces have different affordances. This follows from the discussion of the mimetic iconic interface and the post-geographic interface in Section 2.7.2.

Finally, designers often use an empirical approach to resolving image in their practice, using previous portfolio examples as a precedent for future work. While this approach has clear advantages, it does lack a strategic aspect, which could reveal alternative opportunities in practice. This lack of a holistic approach encourages designers to look to the past. Consequently, at the beginning of a project, this kind of approach could narrow the scope for creativity. There may be a number of reasons for this - technological determinism, convention or through so-called 'user centred' approaches that dwell in known territory. The result is often that designers of virtual spaces create chairs, tables, computers and other iconic references without much thought as to how effectively they communicate. For example, designers seldom question the appropriateness of a 'chair' for a virtual environment where it will never be possible to use the artefact.

A number of contextual assumptions were derived from analysis of communication theory and psychology as discussed in the paper in Appendix 12. A summary of these can be seen below.

- Perception is creative, based on mental models of learnt signs
- The physical world shapes 'language'
- 'Language' alters the way we perceive the world
- The reader not the author produces the meanings from a message
- We have a range of different languages at our disposal
- The form of each language alters the way meaning is conveyed

[204] Loeffler, C., & Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.xiv.

- New technology has facilitated the development of a new three dimensional medium
- Three dimensional media have specific identifiable attributes.

These literature review findings were communicated through a number of propositional papers,[205] as well as at the *Semiotics, Semantics and Dimensionality in HCI Design* conference at the Centre for Design Research[206] in order to receive feedback and peer review.

The primary output from the literature review has been an issues template for framing the research questions and presenting the results. The template has been produced as a consequence of the key topics from the literature review as listed in Table 8, which were aesthetic, interaction, communication, usability and design. This framework was based on cross-cutting issues and was organised according to issues, groups and elements for consideration as shown in Table 5. As a tool it enabled the researcher to take a consistent approach to the research, as well as support the integration of theory and practice through clustering and pattern matching as discussed in Section 4.7.

Issues	**Group**	**Example elements**
Representation	Metaphor	Realism or abstraction, referents, genre
	Dimensionality	2D, 3D, VR
	Sensory	Visual, audio, haptics, olfactory, time, animation
Interaction	Narrative	Travel, way finding, action, education, experience
	Navigation	Mental model, spatial issues, scale
	Presence	Immersion, kinaesthetic
Usability	Conventions	
	Users	Engagement, user-centred design
Design	Other design issues	Guidelines
	The medium	Technologies, Pros / Cons
Technical	Software	
	Hardware	

Table 5: Issues Template as an Output of the Literature Review.

[205] See Appendices 11 & 12 for copies of key papers.
[206] *Semiotics, Semantics and Dimensionality in Human Computer Interface Design.* Centre for Design Research, Northumbria University. 19 March, 1997.

CHAPTER 3.0: METHODOLOGY

This chapter will begin with a review of the methodological approaches employed in the field of research and highlight their relationship to the focal research methodology to be used in this project. It will look at the ontological and epistemological issues raised by the research and specifically provide an overview of the current debates in design research.

3.1 Background

All research methods are fundamentally processes by which society creates and maintains meaningful knowledge. The philosophical theory of knowledge that underpins all research, known as epistemology, seeks to identify and establish the limits of different kinds of knowing.[207] However, the notion of what constitutes knowledge is embedded in a metaphysical discussion about the intrinsic connection between man and reality. If there is a reality that 'underlies appearances' then it is a reality which man can never know. According to Woolley: "Some physicists still believe that there is a single, external universe, one independent of our perception. Indeed according to David Bohm, that is what every physicist really believes."[208]

It is important to note then, that different views on the construction of reality (ontology) inevitably lead to different ways of establishing what is considered to be 'real' (epistemology). It follows, that choosing a particular technique for collecting data and employing particular strategies for validating and communicating the findings will also influence the quality of the knowledge derived. As such, even if we were to assume the possibility of an objective appreciation of reality, this objectivity would be further brought into question as the data is converted into a discourse, by the presuppositions used in the identification and classification of what is experienced. As Potter notes: "...it is not just seeing what is before the eyes but seeing it *as something*; not just a particular colour sensation but a descriptive choice; red, brown with golden speckles or whatever." It is this process of converting 'seeing' into knowing that involves a commitment to a particular kind

[207] Bullock, A., Stallybrass, O. & Trombley, S. (ed.) *The Fontana Dictionary of Modern Thought*. 2nd ed. Fontana Press, 1988, p.279.
[208] Woolley, B. *Virtual Worlds: A Journey in Hype and Hyperreality.* Blackwell, 1992, p.230.

of methodological position, that is, an ontological and epistemological view of reality.[209] To look at the different views on the construction of reality is fundamentally a philosophical undertaking, yet it is important to try to make explicit the underlying parameters and assumptions inherent in the creation of different types of knowledge. Such parameters are described by Guba and Lincoln as being a feature of the individual's paradigm, as Adam and Healy note: "...a paradigm is approximately described as a set of basic beliefs dealing with first principles and representing a worldview that defines, for its holder, the nature of the world, the individual's place in it and the range of possible relationships to that world and its parts."[210] Knowledge about the world, therefore, can be seen as a product of a particular paradigmatic framework. Adam and Healy suggest three fundamental questions to be applied to research to isolate and identify the right paradigm:

> "1. The ontological question, which deals with the form and nature of reality, i.e. 'what is it that can be known about the world';
> 2. The epistemological question, which deals with the nature of the relationship between the researcher and what can be known;
> 3. The methodological question, which deals with the ways in which the inquirer can go about finding out what he or she believes can be known."[211]

The main inquiry paradigms according to Adam and Healy can be seen in Table 6.

Question	**Positivism**	**Interpretivist**
Ontological	Naïve realism, 'real' but apprehend able	Relativism, local and specific constructed realities.
Epistemological	Dualist / objectivist; Findings true.	Transactional / subjectivist Created findings.
Methodological	Experimental / manipulative Verification of hypotheses, chiefly quantitative methods.	Hermeneutical / dialectical, Mainly qualitative with support from quantitative methods.

Table 6: Basic Beliefs of Main Inquiry Paradigms.

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209 Hart, C. *Doing a Literature Review.* SAGE Publications Ltd, 2000, p.51.
210 Guba, E. & Lincoln, Y. Competing Paradigms in Qualitative Research. In: Adam, F. & Healy, M. *A Practical Guide to Postgraduate Research in the Business Area: Coping with Pandora's Box.* Blackhall Publishing, 2000, p.46.

This research is interdisciplinary, which poses a number of challenges for the researcher in particular:

- Clarifying the standpoint from a range of research paradigms
- Understanding the different 'languages' of various disciplines
- Being systematic and integrating the findings effectively (see Section 8.5).

This is noted by Svensson: "Being truly interdisciplinary is rarely easy, as it is all about fuzzy boundaries and being in between established categories."[212] Specifically, this research investigates a number of different disciplines looking at computer science, psychology, communication studies and cultural theory. These disciplines cross several research paradigms including the physical sciences, humanities and design.

If there are different types of knowing, the question remains how different knowledge exists in relation to this research. Research methods fundamentally rely on the premise that knowledge can be systematically uncovered.[213] Here, being systematic not only refers to the organisation of individual research tasks, but more fundamentally to the relationship of all knowledge within a complex system of ideas and relations that gives meaning to bits of information. This is noted by Preece: "The world and its inhabitants are very complex; we can only comprehend or know them if we have patterns of reference and a more or less common kit of ideas, or concepts in order to organise this knowledge."[214] It is therefore integration, or the systematic questioning, inquiring and scrutinising of knowledge that is a key function of research, as Hart notes: "Integration is about making connections between ideas, theories and experience."[215] Or, as Berger notes: "It is knowledge of a system of related information."[216] In this sense it might be a synthesis of methodologies of theories, although equally, it might be the connections between particular knowledge and a wider framework of thinking. This is extended by Geertz, who uses the term 'refiguration' for the process of de-constructing knowledge and restructuring it into new relationships.[217] Either way, the identification of existing patterns within phenomena, or the implications of creating new patterns of data, is one of the key factors in understanding the systematic nature of knowledge.

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[211] Adam, F. & Healy, M. *A Practical Guide to Postgraduate Research in the Business Area: Coping with Pandora's Box.* Blackhall Publishing, 2000, p.47.
[212] Svensson, P. In: Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press, 2003, p.193.
[213] Berger, A.A. *Media Research Techniques.* SAGE Publications Ltd, 1991, p.8.
[214] Preece, R.A. *Starting Research: An Introduction to Academic Research and Dissertation Writing.* Pinter Publishers, 1994, p.7.
[215] Hart, C. *Doing a Literature Review.* SAGE Publications Ltd, 2000, p.8
[216] Berger, A.A. *Media Research Techniques.* SAGE Publications Ltd, 1991, p.13

Much VR research to date has been approached from a scientific standpoint. One key difference between science and design is that science assumes reality to be 'out there', to be objectively discovered, whereas designers perceive reality to be constructed from the interrelation of subjective and objective data. Design practice has both an objective and a subjective component, and, according to De Bono, its inherently ill-defined problems require a fluid combination of rational and intuitive thinking.[218] Design, in contrast to much of science, is creative and relies on a process of inductive rather than deductive thinking. This is a fundamental aspect of design, as Norman Potter notes: "The idea that the myth of creativity can be domesticated, and perhaps told how to behave - in terms at once 'scientific' and 'verifiable' - seems always to fascinate those who feel somehow denied by the myth, or outside its provenance."[219] Until the late 1970s, the majority of research methodologies subscribed to the 'scientific method' and in many cases even the concept of 'research' could be interchangeable with the idea of 'scientific method'. However, if science creates a reality, then it is its own reality based on the confines of logic and reason. As Bruce Archer notes: "...there exists a designerly way of thinking which is both different from scientific and scholarly ways of thinking and communicating, and as powerful as scientific and scholarly methods of enquiry when applied to its own kind of problems." [220] Svensson notes the following requirements for effective interdisciplinary design research:

1. A willingness to break out of discipline specific structures
2. Openness to the ideas and 'language' of people with different backgrounds
3. Knowledge of themes, relevant fields and people in relation to your own field
4. Maintenance of a strong sense of who you are and where you come from.[221]

In respect of the final point, the next section will look at the nature of design methodology, its history and relationship to theory and practice to define the approach of the research, and to position the subsequent case study research methodology in terms of existing design thinking.

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[217] Hart, C. *Doing a Literature Review.* SAGE Publications Ltd, 2000, p.9
[218] De Bono, E. *Lateral Thinking: Creativity Step by Step.* Perennial, 1973, p.282.
[219] Potter, N. *What is a Designer: Things Places, Messages.* Hyphen Press, 1989, p.59.
[220] Archer, B. A View of the Nature of Design research. In: Jacques, R. & Powell, J. (eds), *Design:Science:Method.* Westbury House, 1981, p.34.
[221] Svensson, P. In: Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press. 2003, p.193-4.

3.2 Design Research

The purpose of this section is to contextualise the research by looking at what methods are available to the design researcher, looking in particular at the relationship between the chosen method and the findings, including potential limitations.

As noted in the previous section, the notion of design research presupposes a distinct and definitive nature that is both associated with but different from scientific research, as well as being a sub-set of 'research' in general. There may be two alternative approaches to answering this question, either by evidence of work in the field or by deconstructing and reconstructing a philosophical and practical approach to the question based on theories and terminology. The following discussion will combine elements of both; in the main because there are few long-standing and clearly defined theories of design research and also because design is a subject area characterised by a relatively small number of active design researchers.

Any definition of design research must be flexible enough to encompass a range of disparate design disciplines from fashion design to automotive design. The nature of design as a creative process of planning and execution can be applied to a range of problems in which designers may choose to specialise. In some cases specialisation has taken place with the graphic designer being differentiated from the web designer and the product designer, however, with the introduction of new technologies the boundaries have become less well defined leading to more interdisciplinary approaches. This is noted by both McCoy[222] Svensson[223] and Misera.[224] As McCoy notes: "The design professions are poised on the edge of a new technological frontier where whole new specialisations are being discovered while entire professions may vanish."[225] Current subject definitions, although partial, are essential in clearly stating a position for design research. Bruce Archer broadly defines design research as a systematic method of generating knowledge in design: "Design research is systematic enquiry whose goal is knowledge of, or in, the

[222] McCoy, K. Media, Culture and Technology, *Graphics Discourse PIRA/RSA Lecture,* London, April 15, 1994.
[223] Svensson, P. In: Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press. 2003, p.194.
[224] Misera, T. Industrial Designers, the New Craftsmen of Media? *Multiviewpoint: Shaping the Human Computer Interface,* Design research Society Conference, Centre for Design research, Newcastle, July 02, 1998, (unpublished).
[225] McCoy, K. Media, Culture and Technology, *Graphics Discourse PIRA/RSA Lecture,* London, April 15, 1994.

embodiment of configuration, composition, structure, purpose, value and meaning in man-made things and systems."[226]

If considered in relation to scientific research or social research techniques, from which much of its early work was derived, design research itself may not be considered to have an extensive history, with the Design Research Society (DRS) itself being set up in 1967. To put this in context, industrial design as a 'profession' originated with the mechanisation of the Industrial Revolution and therefore doesn't go back far beyond the turn of the 20th century. This lack of history raises a number of key issues for design, first, the fundamental establishment of a discipline; secondly, the methodological connectivity within a system of ideas and relations; and finally the implications for the development of an appropriate and robust taxonomy. These issues will be looked at in the following section.

An immediate challenge for any design researcher is coming to terms with fact that the current knowledge base of design research is relatively limited, causing it to appear fragmented. As a consequence, it may even be suggested that design research does not qualify as a distinct discipline in its own right, as Archer notes:

> "It is sometimes argued that a test of the existence of a distinctive discipline is the presence of an organised literature containing all the essential ideas in that discipline such that a suitably qualified entrant to the discipline can master its content without depending on the literature of other disciplines. By this test, design research is not yet a distinctive discipline."[227]

Cross concurs when he notes that: "Design is still not accepted as a legitimate discipline of scholarship and research in some of the leading academic institutions."[228] This lack of definition has implications for new researchers seeking to contextualise their work or faced with choosing an appropriate research methodology. In response to this, Archer notes the benefit of relying on use rather than definition: "The advantage of reliance on use rather than definition is its flexibility in the circumstances of a young discipline, where neither the scope nor the vocabulary of the discipline has yet reached stability."[229] However, it should also be noted that a danger of relying on use is that it can cloud the issues further

[226] Archer, B. A View of the Nature of Design research. In: Jacques, R. & Powell, J. (eds.), *Design:Science:Method.* Westbury House, 1981, p.31.
[227] Archer, B. A View of the Nature of Design research. In: Jacques, R. & Powell, J. (eds.), *Design:Science:Method.* Westbury House, 1981, p.34.
[228] Cross, N. (ed.) *Design Studies.* 17(1), Jan 1996, p.1-2.
[229] Archer, B. A View of the Nature of Design research. In: Jacques, R. & Powell, J. (eds.), *Design:Science:Method.* Westbury House, 1981, p.30.

with poor examples of practice making it even harder to see the underlying systematic relations.

This confusion is further exacerbated by the inconsistent use of terminology by design researchers, who inadvertently change meanings or duplicate terms due to the lack of contextual understanding. In scientific, humanities or social scientific research, a significant number of books have been written on research; in contrast design lacked any classic research texts until Laurel's '*Design Research*'.[230] This leaves design researchers to ascertain the current state of play from newsgroups and conference papers, which can lack perspective. The imprecision found in terminology has also contributed to the problem of obtaining consensus on the meaning of knowledge within the field. Durling notes that the establishment of an appropriate taxonomy appears somewhat lacking:

> "...the domain of design is relatively new and the nomenclature typical of subject areas with a long tradition of research has not yet been established; and design itself lies at the intersection of several other disciplines. These are not simple misunderstandings of detail, they are misunderstandings at a more profound level."[231]

This is further extended by Love, who notes:

> "Conceptually and terminologically, design research and design theory is problematic. A neglect of the foundations of design theory has led to terms, concepts and theories being used in a variety of different and inconsistent ways."[232]

As a result of this lack of research tradition, the subject area has not developed an appropriate framework of methodologies, as Findeli highlights: "At a time when many graduate-level university programs in design (Masters degrees and Doctorates) are being created in various countries, design research still lacks a methodological framework which does justice to the originality of the discipline."[233] It is however essential that design has a robust system of ideas and methodologies as it is against this system that new knowledge is measured.

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[230] Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press. 2003.

[231] Durling, D. Design in the UK: Some Reflections on the Emerging PhD. In Durling, D. & Friedman, K. (eds.). *Doctoral Education in Design: Foundations for the Future,* 8 - 12 July 2000, La Cluzaz, France. Staffordshire University Press, 2000, p.318.

[232] Love, T. A Meta-Theoretical Basis for Design Theory. In: Durling, D & Friedman, K. (eds.). *Doctoral Education in Design: Foundations for the Future,* 8 - 12 July 2000, La Cluzaz, France. Staffordshire University Press, 2000, p.45.

[233] Findeli, A. Will Design Ever Become a Science? Epistemological and Methodological Issues in Design research, Followed by a Proposition. In: Strandman, P. (ed.) *No Guru, No Method?* University of Art and Design Helsinki, 1998, p.63.

Design researchers often borrow methodologies from other disciplines - examples include case studies and action research. There are implicit dangers in this approach, which can lead to an ad-hoc approach to design methodology. It has even been suggested by some, that entrants to design research must undertake two research degrees, one in a chosen research topic and the other in constructing an appropriate methodology from a range of disparate sources. For interdisciplinary research this is further exacerbated as the design paradigm lacks sufficient 'sense of who you are and where you come from' (as noted in Section 3.1).

To ensure that research terms are carefully defined it is important that terms are contextualised systematically to highlight commonalities and contradictions. One solution is presented by Love with reference to Hamlyn:

> "... the epistemological and ontological foundations of design research need 'thickening' to allow the concepts , terminology and theories of design research to be 'thinned' to the extent that they have singular meanings."[234]

It is also important to consider design research in its own right rather than being a *laissez-faire,* 'anything goes' amalgam of previous theories. As Preece notes: "Useful research, in purely academic terms, means that which is carried out within the system of knowledge of a particular subject or discipline and contributes to or modifies or even casts doubt on - in fact tests - that system."[235] It is therefore, essential that design research is undertaken in a way that places the resulting findings at the core of design's 'system of knowledge', or the information produced will have little relevance in terms of the discipline. There is currently some disagreement about the definitive nature of design practice and design theory, in particular how these relate to design research as noted in the next section.

[234] Love, T. A Meta-Theoretical Basis for Design Theory. In: Durling, D & Friedman, K. (eds.). *Doctoral Education in Design: Foundations for the Future*, 8 - 12 July 2000, La Cluzaz, France. Staffordshire University Press, 2000, p.46.
[235] Preece, R.A. *Starting Research. An Introduction to Academic Research and Dissertation Writing.* Pinter Publishers, 1994, p.7.

3.3 Relationship of Research to Design Practice

Design as a profession is fundamentally based in practice, so it is not surprising that it is at odds with traditional approaches to research, which rely heavily on theory and are measured by outcomes that are neither designerly nor the result of design practice. Yet it is important to understand the difference between research and practice, as Durling notes: "Research and practice co-exist as different categories of creative endeavour, and should not be confused as being identical categories."[236] He continues: "Research has goals quite different to practice. It asks questions, selects appropriate methods, tests the questions, analyses the results, and disseminates the conclusions unambiguously...Practice does not have these goals."[237] In this sense research is distinctly different to practice, yet can be used to discover information about practice as is the case with this project. This raises the issue of how the research findings should be constructed to have meaning for practising designers.

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236 Durling, D. Design in the UK: Some Reflections on the Emerging PhD. In Durling, D. & Friedman, K. (eds.). *Doctoral Education in Design: Foundations for the Future,* 8 - 12 July 2000, La Cluzaz, France. Staffordshire University Press, 2000, p.325.

237 Durling, D. Design in the UK: Some Reflections on the Emerging PhD. In Durling, D. & Friedman, K. (eds.). *Doctoral Education in Design: Foundations for the Future,* 8 - 12 July 2000, La Cluzaz, France. Staffordshire University Press, 2000, p.325.

3.4 Design Methodologies

There are numerous research methods available to the researcher across different subject disciplines. It seems clear that particular disciplines, in the main, favour particular methods, for example the historical relationship between the sciences and experimentation, or the use of case studies in the social sciences. However, each method employs a different system of investigation and one can therefore link each method to a particular setting or event to be investigated. According to Yin, each mode of investigation approaches three key conditions in different ways, as follows: "The three conditions consist of (a) the type of research question posed, (b) the extent of control an investigator has over the actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events."[238]

Yet it is the methodology that is singularly the most deterministic component of any research project and is intrinsically linked with the validity of any results or conclusions within a given context. It is therefore essential that an appropriate review and interrogation of different methods is undertaken in order to identify the benefits and shortcomings of a particular research method in terms of the context of the research. Blaxter *et al* have categorised research methods into families, approaches and techniques (See Table 7).

Research families, approaches and techniques		
Research Families	*Research Approaches*	*Research Techniques*
Quantitative or Qualitative	Action Research	Documents
Deskwork or fieldwork	Case Studies	Interviews
	Experiments	Observation
	Surveys	Questionnaires

Table 7: Categorisation of Research Methods According to Blaxter, L., Hughes, C. & Tight, M. *How to Research*. Oxford University Press, 2000, p.61.

A number of different strategies for investigating complex phenomena are currently available to the researcher including the experiment, the history, the survey and archival analysis. Within this, design researchers tend to have favoured methods including case studies, action research (borrowed from education) and practitioner-led reflective practice. Additionally, media studies researchers have developed specific techniques for reading images and cultural artefacts including content analysis, compositional interpretation and semiology.[239] In contrast to content analysis and compositional interpretation, semiotics is a more comprehensive methodological strategy. As Rose notes: "Semiology offers a very full box of analytical tools for taking an image apart and tracing how it works in relation to broader systems of meaning."[240] However, each method deploys different techniques which have implications for the communicability of the results.

This research is taking a qualitative approach using case studies with the researcher predominantly acting as objective non-participant, observing design practice and gathering data using structured interviews and observation. A case study methodology was chosen because of the contemporaneous nature of VR and because of the complexity of the relationship between the subject matter and the context of use. In this respect the events researched are being investigated in their natural context, from a holistic standpoint including multiple variables. The choice of focal methodology will be addressed in the next chapter.

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[238] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.4.
[239] Rose, G. *Visual Methodologies: An Introduction to the Interpretation of Visual Materials.* Sage Publications Ltd., 2001, p.69.
[240] Rose, G. *Visual Methodologies: An Introduction to the Interpretation of Visual Materials.* Sage Publications Ltd., 2001, p.69.

CHAPTER 4.0: DETAILED DISCUSSION OF THE KEY METHODOLOGIES EMPLOYED IN THE RESEARCH PROJECT

This chapter will look in detail at the methodologies employed in the research project. The purpose of this section is to outline the procedural elements for the research, including issues of construct validity, internal and external validity, reliability, the study's questions and propositions, units of analysis and rival theories. It will also highlight in detail the research process, including a discussion of the case study method and data gathering techniques. The research project methodology will be summarised below, followed by a discussion of each technique employed.

4.1 An Overview of the Research Approaches and Techniques

The chosen methodology for this research was a qualitative one, using case studies and involving interviews, observation and documents as research techniques and utilising expert forums to analyse and refine the outputs. Due to the interdisciplinary approach, an extensive literature review was undertaken to familiarise the researcher with state-of-the-art thinking and key terminology across different fields. This aimed to address a broad range of subjects from which to distil the relevant issues, paradoxes and dilemmas. This analysis led to a number of propositions which were subsequently refined and tested through expert and peer review discussions at an expert forum organised by the researcher at British Telecom. The key outputs from the forum were a refinement of the model, definition of issues and key questions to be posed during the case study investigation. A case study approach was used because of the contemporaneous nature of HCI development, because of the lack of manipulation over the events and because of the complexity of the relationship between the chosen representation and the context of use.[241] For this process, six case studies were investigated in two phases. Here the researcher acted as an objective reviewer considering the nature of the projects, their outcomes and significance to the research project. Semi-structured interviews were employed to elicit first-hand data about design practice in context. These interviews were based around a set of open-ended questions to ensure the consistent treatment of the different case studies being examined. In addition to the interviews, the case studies employed multiple types of evidence, including diaries, videos and documentation to provide the triangulation of data sources. Between the first and second set of case studies a model of communication was refined and presented to a group of experts for peer review. This event focused on the application of the technologies of VR and three-dimensional imagery from the perspective of the design practitioner. Following from this, a cross-case analysis was undertaken which resulted in the development of a revised communication model to present the results.

The method was developed to integrate theory and practice through a cyclical process of divergent and convergent thinking, with key review phases, leading to a definitive model of communication as highlighted in Figure 16. This divergent-convergent approach was effective for integrating the knowledge of different disciplines (as noted in Section 3.1) as well as providing maximum opportunity for innovation. This is noted by Rhea, who suggests: "Broader thinking also helps us break out of the current mindset."[242] A secondary function of the divergent-convergent process was to offset the narrowing effect of interviewing experts with a defined frame of expertise as also noted by Rhea.

> "Discovery research is about finding new frontiers. We often use expert interviews when studying a category, and we find that our most productive and enlightened experts are outside the category. Their perspective and frame of reference are unique – exactly what we need to challenge more entrenched thinking."[243]

In this respect the use of a range of experts in the colloquia and forum events both broadened and deepened the scope of the investigation.

Furthermore, this method facilitated the integration of theory and practice, and was critical to test the model with real examples, as well as to present the case studies to design practitioners. The resulting model of communication categorises images and creates a visual taxonomy to communicate the theory to practising designers, the final outcome being the identification of the unique virtues and constraints of VR, as indicated by the research.

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[241] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.13.
[242] Rhea, D. In: Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press. 2003, p.148.
[243] Rhea, D. In: Laurel, B. (ed.) *Design research, Methods and Perspectives.* The MIT Press. 2003, p.148.

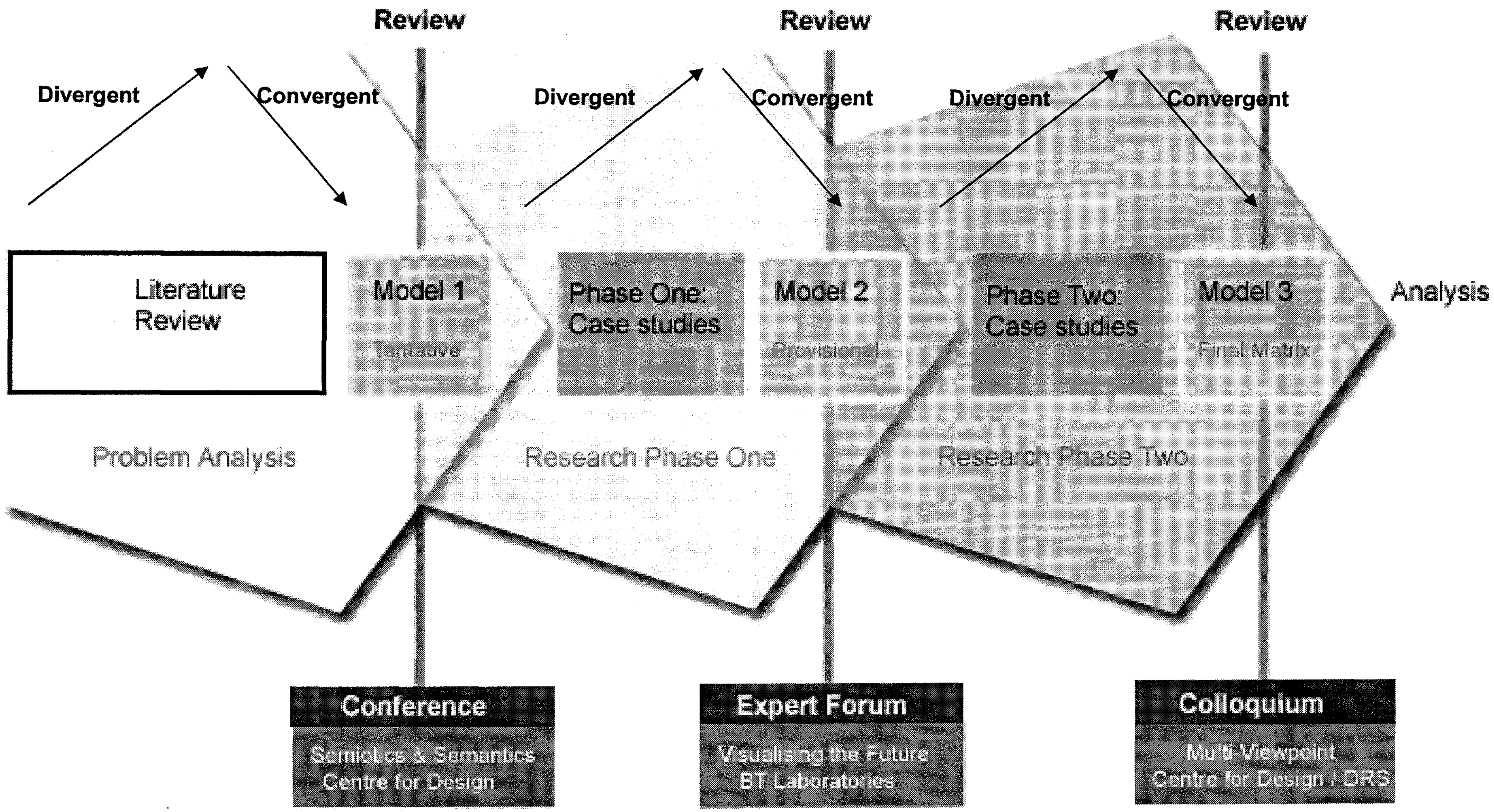

Figure 16: Divergent and Convergent Process of Investigation, Development, Planning and Review.

4.2 Determination of the Methodology for the Literature Investigation

This section describes the methodology for the literature search. It will highlight some of the important criteria applied to the cross-referencing and the detailed investigation of the context of the research project. The literature search standpoint was based on an arts and humanities philosophy which aimed to distil from a broad analysis the relevant issues, paradoxes and dilemmas. This was achieved by a divergent-convergent process of filtration as highlighted in Figure 17.

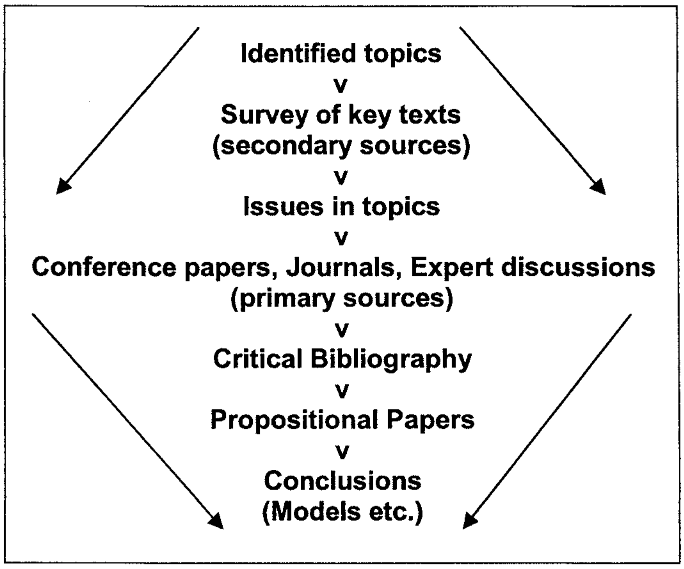

Figure 17: Literature Search Process of Convergence and Filtration.

This involved the combination of primary and secondary sources in two identifiable stages, the first stage involving a review of secondary sources including textbooks and the second stage being more specifically structured to review primary sources including journal articles and conference presentations.[244]

The literature search initially approached a broad range of subjects including: Communication Studies (Semiotics), Interaction Design, Information/Graphic Design, Psychology (particularly perceptual psychology), Cultural Theory, Sociology, Design Theory (product semantics) and issues relating to human-computer interface and multimedia. This broad foundation was essential in an interdisciplinary study to combine different subject expertise as discussed in Section 3.1.

In addition to the literature search, consultation with experts at BT, freelance design links and academic discussions at key conferences, and within Northumbria University's Centre for Design Research all developed the issues.[245] The literature search analysed a broad range of subjects leading to general conclusions and interpretations, which were further refined through primary sources before being tested through expert events and peer review discussions.

[244] Burns, R.B. *Introduction to Research Methods.* 4th ed., Sage Publications Ltd., 2000. p.25.
[245] See Appendix 1 for a chronology of the project including key events attended.

4.3 Determination of the Methodology for the BT Expert Forum – Media and Contextual Issues

To develop and refine the issues raised in the literature review, a process of peer review and analysis followed through the use of an expert forum. The intention was to create an inclusive, multi-disciplinary theoretical basis from which to consider the subject area, and to cross-relate these issues with those already raised in the literature review and propositional papers. It was considered that an expert forum would allow areas of commonality and divergence to emerge and reinforce or question the initial assumptions. The aim of the forum specifically was to contextualise the research by using key experts in the field to tackle a range of questions on the future development of three-dimensional media and VR.

4.3.1 Criteria for the Selection of the Panel Members

The forum was focused on insights from a variety of disciplines to ensure the research was multi-disciplinary in approach. The experts were identified through the literature review as being commentators on the subject. It was important that the group of attendees was considered suitably representative of the breadth of knowledge necessary to obtain valid findings and that it had insight into the issues already raised by the communication model.

4.3.2 Methodology for the Forum

A visit was made to brief the speakers prior to the event to familiarise them with the aims and objectives of the day, and participants received an overview document highlighting the research to date as well as the aims of the forum. During the event the researcher remained an objective observer, whose role was to witness and record the proceedings. A presentation which highlighted the issues addressed by the research to date was felt to be appropriate to focus the discussion and if necessary provide any additional areas of interest to the debate. To maintain the objectivity of the process, this presentation did not represent any findings, but revealed the assumptions upon which the research was being undertaken (see Appendix 6). These would fall roughly into two categories - research assumptions and research questions. The research assumptions represented the explicit choices made by the researcher that allowed the subject matter to be defined and the questions to be raised. The research questions were aimed to focus the discussion, relating to the kinds of questions the research had addressed.

4.3.3 Data Collection and Treatment

A video recording was made of all the speakers using video conferencing equipment. Additionally, shorthand notes were taken during the event by the researcher and the completed notes were subsequently disseminated to the speakers for comment or reflection.[246]

[246] See Appendix 5 for the raw data.

4.4 Determination of the Methodology for the DRS Expert Colloquium – Issues in Practice

In contrast to the first expert forum, the second event focused on issues in practice. The aim of the event was to draw expert opinion on the subject and to present the findings of the case studies through the primary communication models.

4.4.1 Criteria for Selection of Key Speakers

The speakers represented expert practitioners in the field of Virtual Reality, computer aided design and 3D modelling. Panel members were selected based on their perceived understanding of the practical issues inherent in their chosen medium. This was in direct contrast to the theoretical standpoint of the first forum, and was intended to provide insight into the issues from a designer's perspective.

4.4.2 Methodology for the Event

The agenda initially was to briefly contextualise the day with presentations by the researcher, followed by expert practitioners describing their experiences in creating digital designs. The speakers were invited to prepare a 15-minute presentation on a topic chosen by the researcher. The tentative titles were created to provide the necessary focus to the event without being overly deterministic.

4.4.3 Data Collection and Treatment

A video recording of the event was made, from which key issues were transcribed. Additionally, speakers submitted their presentations for the researcher to review after the event.[247]

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[247] See Appendix 7 for the raw data.

4.5 Case Study Method

A case study methodology was used to investigate design projects within the design studio context. Evidence of work in the field was used as the subject matter of the investigation. Yin characterises the use of the case study in the following way:

> "1. A case study is an empirical inquiry that:
> - investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident."[248]

In this sense, the case study differs from the experiment, which typically can selectively investigate different factors and be objectively divorced from the context. Whereas the experiment enables the researcher to define how the variable can affect their results, in some investigations it is not possible to remove the events under investigation from the context without detrimentally affecting the results. In such instances, the case study provides a suitable mode of investigation, which can be sympathetic to complex information within its natural context. Further to this, Yin continues:

> "...2. The case study inquiry
> - copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result.
> - relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result.
> - benefits from the prior development of theoretical propositions to guide data collection and analysis."[249]

The development of the case studies in this research project followed three stages; define and design, prepare and collect, and analyse and conclude. These stages are highlighted in Figure 18:

[248] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.12-13.
[249] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.13.

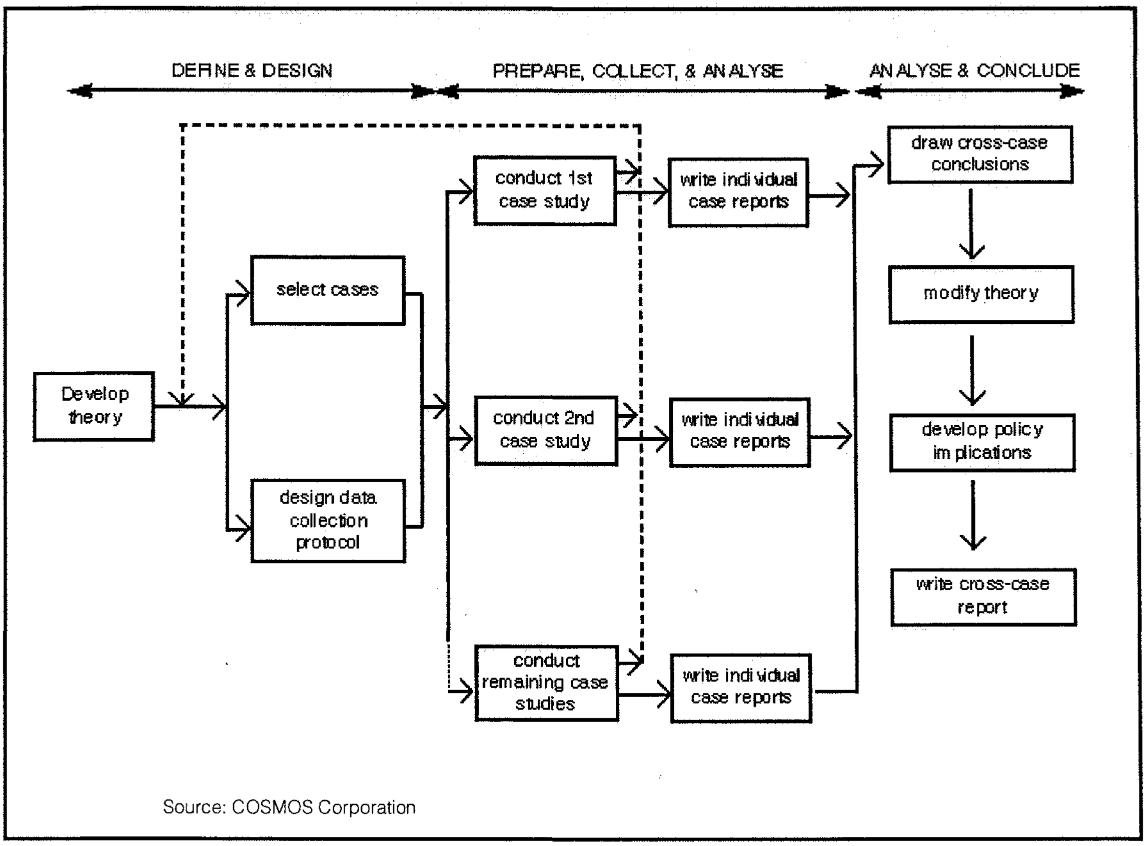

Figure 18: Case Study Methods – Source: COSMOS Corporation.

4.5.1 Overview of the Primary and Secondary Case Studies

Two sets of case studies were investigated: three early case studies - 'Sculptural Metamorphosis', 'Knowledge=Power' and 'Emotional Icons', and three later case studies – 'Call Waiting', 'Concept 2010' and '3D Retail'. The initial phase of the process was a familiarisation activity to investigate early hypotheses, to identify critical issues and to highlight suitable questions to be asked of the secondary case studies. The findings from this phase were therefore formative. These primary case studies did not involve interviews and were predominantly based on a reflection on previous practice by the researcher. In addition to this reflection, the researcher reviewed project documentation and undertook informal discussions with the design practitioners where relevant. The early cases were used to identify quickly the scope for the later investigation and to review early findings from the literature review. The outputs of these case studies were individual summary reports on the cases and formative communication models. These findings combined insight from the literature review with the case study findings.

In contrast, the second phase case studies benefited from the findings of the preliminary case studies and further research into case study methods.[250] These case studies were therefore more structured, in-depth and focused. The process was meticulously planned and involved semi-structured expert interviews, documentation review and analysis of the 3D interfaces. The findings from the second phase of the case studies were therefore more robust and reliable in methodological terms. The discussion in this chapter refers predominantly to the process undertaken in the secondary case studies. These case studies were documented in individual case study reports (summarised in Chapters 5 & 6) prior to a cross-case analysis. The outcome of the secondary case studies was a refined model of communication, illustrated in Chapter 6.

Each set of case studies included the use of a pilot case study to enable the researcher to refine the process. Following each phase of case studies a forum was held to review the findings with experts. Figure 19 illustrates the relationship between the two phases of case study investigation including a process of refinement across the two phases.

[250] A six months internship at BT allowed the researcher to develop further methodological processes as outlined in Appendix 1.

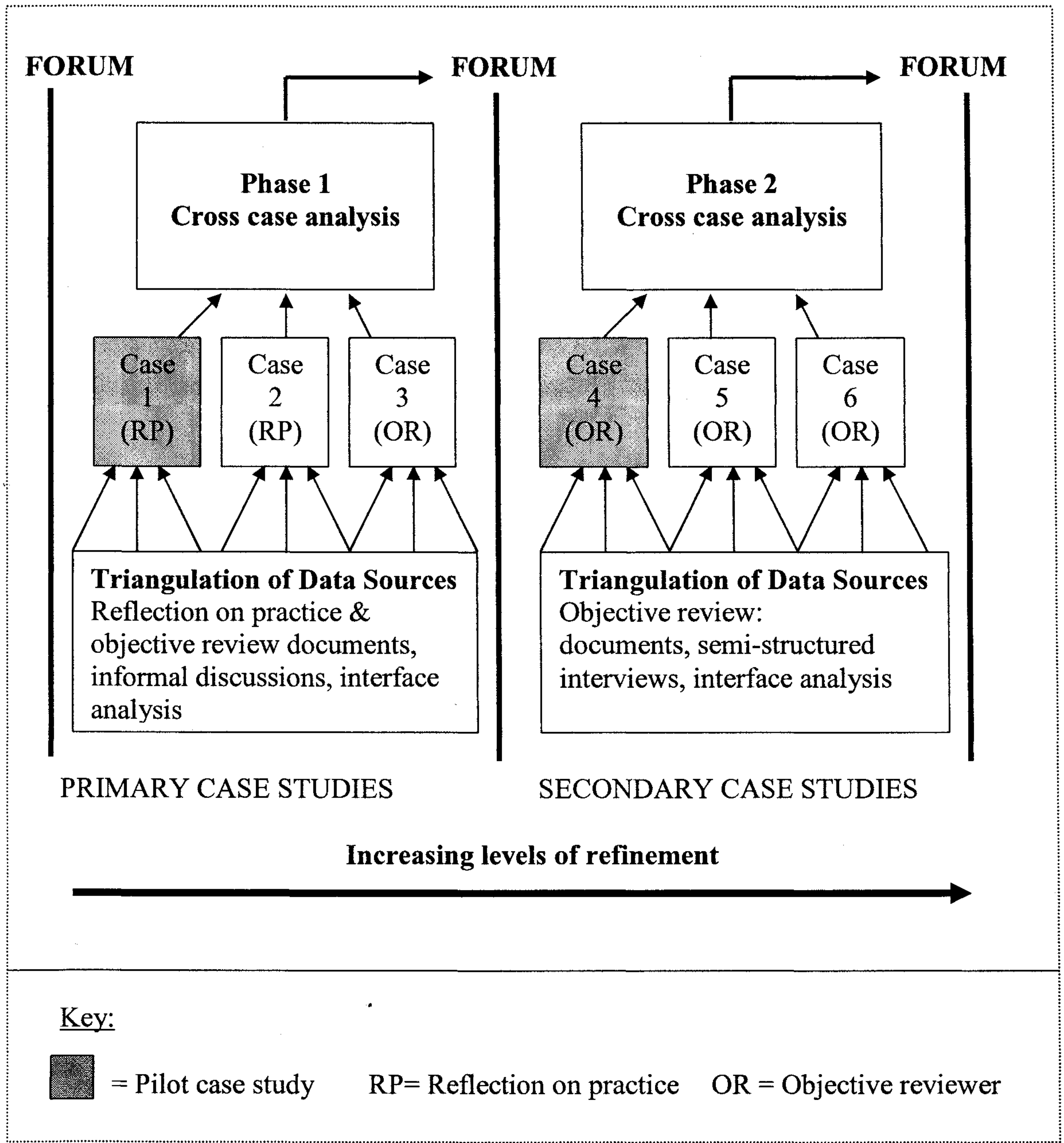

Figure 19: Overview of Case Studies, Showing Relationship of the Different Research Methodologies and Techniques, based on Yin's Model of Case Study Research Methods.

4.5.2 Single Case Versus Multiple Case Design

The aim of the multiple case design was to ensure the most robust results through a replication logic, as noted by Yin: "...a major insight is to consider multiple cases as one would consider multiple experiments - that is to follow a 'replication' logic."[251] The number of replications was considered appropriate for the nature of the study being undertaken:

> "...you may want to settle for two or three literal replications when the rival theories are grossly different and the issue at hand does not demand an excessive degree of certainty. However, if your rivals have subtle differences or if you want a high degree of certainty, you may press for five, six or more replications."[252]

This process required the researcher to undertake a number of different research techniques including observation, interviews with practitioners and compiling of documentation both physically and electronically. This further reinforced the need for the case study methodology as Yin notes:

> "...the case study's unique strength is its ability to deal with a full variety of evidence - documents, artefacts, interviews, and observations - beyond what might be available in the conventional historical study. Moreover, in some situations, such as participant observation, informal manipulation can occur."[253]

Within each phase of case studies, the design projects were selected on the basis of predetermined criteria (see criteria for selection in Section 4.5.4), as well as predicting similar results (a literal replication). This was in contrast to a theoretical replication that may have used contrasting results to test the initial hypothesis. It is important to emphasise that the comparison of individual cases was undertaken within a phase rather than across phases. This was due to the differences in the methodology for the different phases and because the case study examples were selected and analysed based on different criteria, making direct comparison unreliable.

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[251] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.45.
[252] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.50.
[253] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.8.

4.5.3 Extent of Control Over the Events Being Studied

In two of the early case studies, the researcher's involvement consisted of reflection on practice while in another the role was that of objective observer (as shown in Figure 19). This was due to the case studies being selected from previous work undertaken by the researcher in design practice. In contrast, during the secondary case studies the researcher acted as an objective reviewer considering the nature of the projects, their outcomes and significance to the research project as an observer.

Due to the contemporary nature of state-of-the-art research at BT Laboratories, the researcher was able to visit the site at Adastral Park for six months to investigate the work in context. This also had a bearing on the choice of case study for the research that Yin notes: "The case study is preferred in examining contemporary events, but when the relevant behaviours cannot be manipulated."[254] The case study differs from a history in that it adds two sources of evidence: direct observation and systematic interviewing.[255] In this research, direct observation, documentation collection and systematic interviewing were used to triangulate the sources of evidence, thereby allowing any individual anomalies to be minimised.

4.5.4 The Criteria for Selecting the Case Studies (Sampling)

In the selection of examples for the case studies the following issues needed to be considered:

(a) Definition of an appropriate sample
(b) Required group size and sample size
(c) Appropriate method of sampling individuals or groups, i.e. random or opportunity sampling
(d) Access to samples
(e) Controls to be set up to record the actions and reactions when the test is not carried out and when the sample is unaware they are a control.[256]

The case studies were chosen primarily because they represented examples of three-dimensionality in HCI and VR. Of the projects that were underway, few were accessible for in-depth research due to the inaccessibility of the original software used and commercial sensitivity. The literature search therefore, revealed very few exemplary

[254] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.8.
[255] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.8.
[256] Coolican, H. *Research Methods and Statistics in Psychology.* Hodder & Stoughton, 1999, p.24.

projects. This caused an element of 'opportunism' in the selection of case studies. To provide suitable access to in-depth examples, the projects were chosen from a range of work being undertaken at BT and by the researcher. The accessibility of the projects was a result of BT's support as a collaborator, enabling the researcher to participate in pre-competitive research and commercial project work. Such projects were considered state-of-the-art due to BT's vast investment in futures research and the researcher's experience of advanced computer facilities in commercial design practice. A form of non-probability sampling was used, which can also be described as purposive, purposeful or criterion-based sampling.[257] In this way, a set of criteria was devised against which potential examples were measured for each set of case studies.

4.5.4.1 Criteria for Primary Case Study Selection

The primary case studies included work previously undertaken by the researcher. These case studies were investigative - they were undertaken to identify key issues to be looked at in the secondary case studies. The main criteria for selection was the case studies ability to communicate additional meaning not demonstrated successfully through alternative representations such as text or two dimensional images. As such the following criteria were considered important:

1. Demonstration of three dimensionality, using concepts of spatiality, perspective, multiple vantage points and interaction
2. Little or no reliance on textual windows or manuals
3. Projects with a clearly defined objective to convey information to the user to direct their actions intentions or beliefs.

These criteria were applied retrospectively due to two of the projects being reflection on practice, based on work already completed by the researcher and the other being the project on which the BT sponsorship was secured. Criterion one relates to the essential three-dimensionality of the interface as a focal part of the interaction, with criterion two noting the low priority to more traditional textual interfaces. Criterion three relates to the projects' communication function. The primary case studies utilised three-dimensionality both in the form of linear animation and VR (See Table 4 for a breakdown of the three dimensional image).

[257] Burns, R.B. *Introduction to Research Methods.* 4th ed., Sage Publications Ltd., 2000, p.465.

4.5.4.2 Criteria for Secondary Case Study Selection

The secondary case studies built on the primary case study findings and proposed a more refined set of selection requirements. The secondary case study projects were undertaken entirely by BT, with the researcher acting as an objective observer in the process. The criteria were derived collectively from the literature review, early case studies and question framework. The following were deemed important for the secondary case study selection:

1. Part of the project (or whole) should be represented in a three dimensional manner using multiple viewpoints, interactivity, mock 3D perspective and changing scale
2. The interface does not require pull-down menus or windows, or manuals to guide actions
3. Actions / instructions / feedback are provided by the form itself
4. Clearly defined objective, e.g. to inform actions of user
5. Clearly defined audience (an awareness of the audience's previous experience)
6. Clearly defined toolset, i.e. computer interface as the medium using software packages such as Superscape and VRML
7. Demonstration of one or more of the key virtues as identified from the literature review and primary case studies.

Two research meetings at BT focused on the case study selection criteria with the intention of identifying from a range of projects the most suitable for the study. These were projects which were recently completed or substantially in progress and which fit the criteria outlined above. Additionally, the projects selected were of a sufficient scale to apply the research questions meaningfully. The secondary case studies were entirely comprised of VR examples, using Superscape software on PCs (See Table 3 for a comparison of hardware systems).

4.5.5 Case Study Research Design

For the case studies, five components of a research design were especially important: the study's questions, its propositions, its unit(s) of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings.[258] This section will look at each of these elements.

[258] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.20.

4.5.5.1 The Study's Questions (substance and form)

To focus the investigation, it was necessary to describe the specific research question. This was broken down into two parts, its substance and its form. The substance identified what the study was about, whilst the form conveyed the kind of question being asked: a who, what, where, why or how question.[259] For this research, each case study asked: What are the key functional and aesthetic characteristics of a three-dimensional user interface? A second question sought to relate this to existing two-dimensional interfaces by asking: How does the three-dimensional user interface differ from the two-dimensional user interface? These questions used both 'what' and 'how' questions, and thus reflected the exploratory and descriptive nature of the investigation. Yin notes that if the research question focuses on 'how' or 'why' questions then the case study is a useful mode of investigation. Additionally, if the research question focuses on particular types of 'what' questions it might be exploratory, in which case any strategy can be used.[260]

4.5.5.2 The Study's Propositions

The purpose of the study was to find out the unique virtues and constraints of the three dimensional user interface in VR. The criterion for successful exploration was that commonalities would be found across cases, relating to analytic generalisation of a theory / list of virtues and constraints.

4.5.5.3 The Units of Analysis

The units of analysis were individual Virtual Reality or multimedia projects that employed both the two and three-dimensional user interface. Here a distinction was made between the two and three-dimensional aspects, with the three-dimensional being the units of analysis whilst the two dimensional aspects were employed to fulfil the second part of the research question.

[259] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.7.
[260] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.5

4.5.5.4 Rival Theories

Inherent in complex subject matter is the potential for rival explanations for the case study results. Yin notes the dangers of only attending to evidence which supports a single point of view, suggesting that the investigator should be proactive in seeking out different explanations: "To represent different perspectives adequately, an investigator must seek those alternatives that most seriously challenge the design of the case study."[261] This reduces the potential for bias on the part of the researcher and results in a more robust case study.

However, a rival theory can be beneficial to the case study if deliberately included in the design of the case study. For this study, possible rival theories might include software or hardware technological determinism (See Section 2.4.4 for full discussion). In this case it might be seen that the results are not formed by inherent factors in three-dimensionality, but rather biased by the particular software or hardware capabilities used to create the virtual environments (this relies on the premise that it is possible to divorce the software capabilities from the nature of the medium.) In order to counter this, the examples used included case studies that have employed at least two different types of software in their creation, e.g. Superscape and Alias. Additionally, the two-phase case study programme was intended to highlight changes over time that might be attributable to hardware capability changes.

4.5.6 Validity of the Case Study Methodology

It is important to note that in the absence of random sampling or standardised instruments, the maintenance of validity is harder to achieve in the case study.[262] Here the main techniques for ensuring validity included data triangulation and the integrity of the researcher in maintaining a chain of evidence and seeking to interrogate their own interpretations. As noted by Adam, "triangulated designs constitute more holistic research vehicles, particularly good at illustrating elements of the context and able to take the researcher further down the road to generalisation."[263]

[261] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.149
[262] Burns, R.B. *Introduction to Research Methods.* 4th ed., Sage Publications Ltd., 2000, p.476.

Construct validity refers to the adoption of correct operational measures for the concepts being studied.[264] This is important as it minimises the subjective judgements which might otherwise affect the data collection. To ensure construct validity the case studies utilised multiple sources of evidence (selected to converge along the relevant lines of inquiry) and maintained a chain of evidence (where the history of data was carefully logged). See Figure 19 for a breakdown of the sources of evidence leading to different case studies. Three tactics were therefore used in the secondary case studies to ensure construct validity, namely:

1. Multiple sources of evidence - selected to converge along the relevant lines of inquiry
2. A chain of evidence - where the history of data was carefully logged
3. The draft case study report was reviewed by key BT experts.

The internal validity refers to how well the findings match the reality. However, this 'reality' is subjective, as Burns notes: "In a case study, what is being observed is a participant's notion or construction of reality, their understanding of the world. What *seems* true may be more important than what *is* true."[265] In this respect the researcher's integrity is essential, as their inferences may have a bearing on the results. However, this is not necessary with descriptive or exploratory case studies, according to Yin: "Note that this logic is inapplicable to descriptive or exploratory studies (whether the studies are case studies, surveys or experiments), which are not concerned with making causal statements."[266]

External validity is important to dictate the way the case findings are generalised beyond the case study being investigated. With single case studies this is difficult, as Yin highlights: "Critics typically state that single cases offer a poor basis for generalising."[267] However, in cross-case analysis some inferences can be made towards generalising the findings, which can be in the form of analytic generalisation. As Yin continues: "In analytic generalisation, the investigator is striving to generalise a particular set of results to

[263] Adam, F. & Healy, M. *A Practical Guide to Postgraduate Research in the Business Area: Coping with Pandora's Box.* Blackhall Publishing, 2000, p.59.
[264] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.33.
[265] Burns, R.B. *Introduction to Research Methods.* 4th ed., Sage Publications Ltd., 2000, p.476.
[266] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.35.
[267] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.36.

some broader theory."[268] In this research the method of cross-case analysis has been used to enable patterns to emerge across the examples studied.

4.5.7 Reliability

Clear documentation of the chain of evidence was created to allow subsequent investigators to review the study findings and ensure reliability. Reliability refers to the degree of consistency with which different observers will find similar results on different occasions.[269] The aim was, that if a researcher were to re-examine the case study, they would arrive at the same conclusions. However, this does not mean that they would find the same results with different case studies, as might be the case with experiments that aim to 'replicate' the findings with a different experiment under the same conditions. The ultimate goal was to ensure that the findings and conclusions were consistent to minimise any errors and biases in the study.

4.5.8 Generalising from Case Study to Theory

This research used analytic generalisation to compare the results of the case studies. This comparison was based on a theory which developed as an outcome of the research stages. As noted by Yin:

> "Under these circumstances, the method of generalisation is 'analytic generalisation', in which a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed."[270]

The results of the cross-case analysis were subsequently compared to previous findings and to a review brainstorm session to look for commonality across phases (as illustrated in Section 7.1.1).

[268] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.36.
[269] Silverman, D. *Doing Qualitative Research. A Practical Handbook.* Sage Publications Ltd., 2000, p.175.
[270] Yin, R. K. *Case Study Research, Design and Methods.* 2nd ed., Sage Publications Inc., 1994, p.31.

4.6 Semi-Structured Interview Method

A number of interview methods exist, including unstructured, semi-structured and structured interviews. In this research semi-structured interviews were used to access primary information from designers for the case studies. Interviews were appropriate for this research because of the low number of case studies being investigated; because the researcher was in the context (as an observer), therefore cost implications of interviewing did not apply; and because the relationship between the interviewer and interviewee was already established, ensuring a high level of communication. The advantages of a semi-structured interview technique, according to Burns, are as follows:

- With the contacts being repeated, there is a greater length of time spent with the informant, which increases rapport
- The informant's perspective is provided, rather than the perspective of the researcher being imposed
- The informant uses language natural to them rather than trying to understand and fit into the concepts of the study
- The informant has equal status to the researcher in the dialogue rather than being a guinea pig.

However, Blaxter notes that the considerable time necessary to transcribe and analyse the data could be a potential disadvantage of interviews.[271] In response to this, the researcher taped the interviews and also took shorthand notes during the conversation to highlight key issues. The videos were later transcribed to capture subtle nuances and seemingly 'throwaway' comments. The raw data of the full set of notes can be found in Appendix 3.

The interviews were conducted at BT labs using Virtual Reality software running on PCs as shown in Figure 20.

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[271] Blaxter, L., Hughes, C. & Tight, M. *How to Research.* Oxford University Press, 2000, p.156.

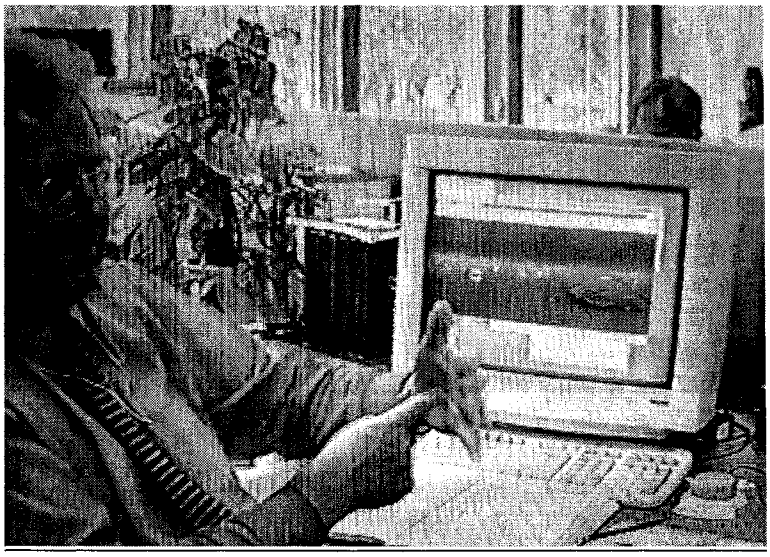

Figure 20: Screenshot of Video from Semi-structured Interview.

4.6.1 Interview Questions

The semi-structured interview questions were established as a consequence of findings of the literature search, expert forum and the preliminary case studies. Primarily, the aim of the questions was to interrogate the secondary case studies in relation to the set of functional aspects identified in the literature review. However, they were also designed to highlight commonalities, such as hardware, software and scope across case studies. The interviews consisted of 146 questions, which were designed to be open-ended and not leading.[272] The questions were therefore not intended to be too prescriptive and not all of the questions were asked of each case study. In particular, the development of ideas through interaction with the expert was important, allowing the design expert to influence the way that the questions led their own description of the work. However, it should be noted that the lack of control over the interpretation by the interviewee of the questions language and terminology could be seen as a limitation. As such, the function of the questions was to ensure the treatment of the different case studies were consistent, yet to allow scope for the interviewee to take the discussion in new areas.

[272] A full list of questions is included in Appendix 2.

4.7 Analysis Plan

The raw data from the case study interview transcripts were reviewed twice to highlight relevant content utilising content analysis techniques. The primary review being *informal* (occurring immediately, with the researcher involved in the case) and the second being *formal* (occurring after a period of time had elapsed).[273] Individual cases were written up and summarised prior to cross-case analysis. The cross-case analysis involved the production of a meta-matrix ordered by cases.[274] This content was then correlated with issues found in the literature review and the primary case studies. This was also matched with insights from a 3D media brainstorm and results from the events. From this the complete list of issues was mapped and patterns identified as shown in figure 21 (See Appendix 8 for a full set of images of issues mapping).

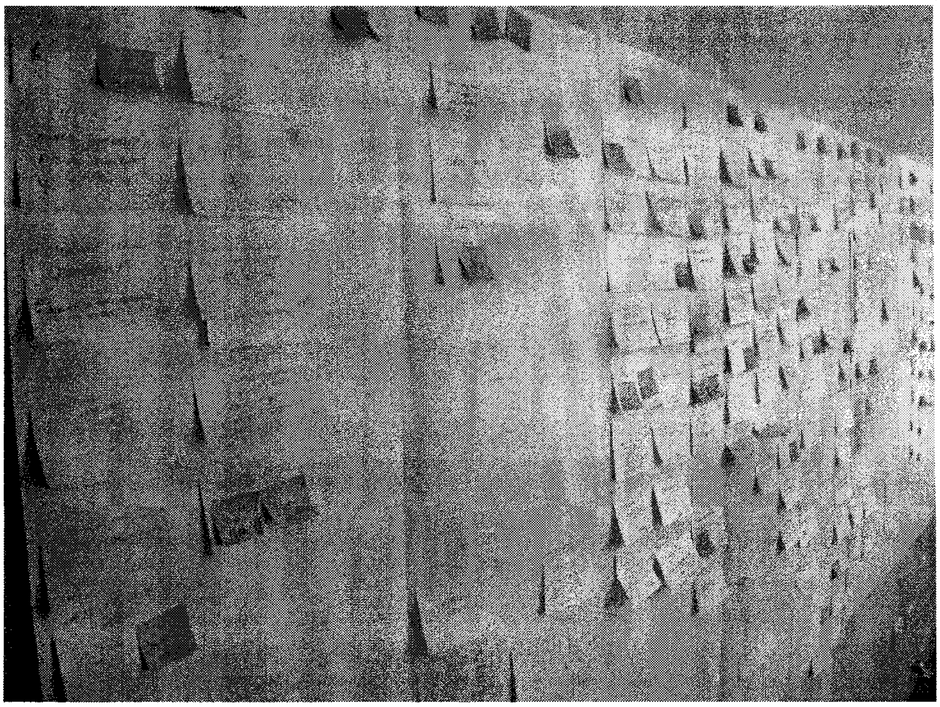

Figure 21: Example of Issue Mapping.

[273] Robson, C. *Real World Research. A Resource for Social Scientists and Practitioner-Researchers.* Blackwell Publishers Ltd, 1999, p.378.
[274] Robson, C. *Real World Research. A Resource for Social Scientists and Practitioner-Researchers.* Blackwell Publishers Ltd, 1999, p.400.

These patterns were then distilled into a set of key issues which were fed into the final communication model. This model was developed to express the emerging research themes through a theory-building technique. The process of theory building followed the divergent-convergent model illustrated in Figure 22.

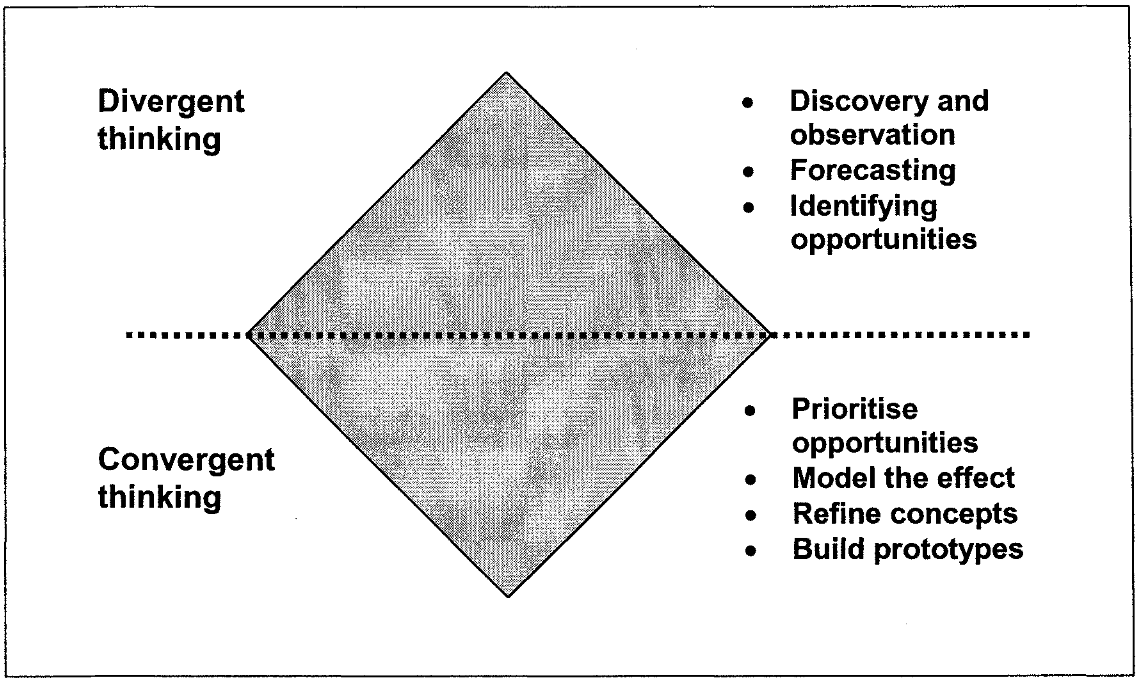

Figure 22: Divergent and Convergent Analysis.
Developed from Rhea, D. In: Laurel, B. (ed.) *Design Research, Methods and Perspectives.* The MIT Press, 2003.

4.8 What is the Relationship between the Chosen Method and the Findings, Including Potential Limitations?

Case studies have been criticised for the following reasons:

- Failure to control the subjective elements
- Their time consuming nature
- Lack of evidence for scientific generalisation.

This research has focused on creating a broad theoretical framework from which to approach the subject of interface design. This has enabled conjecture about aspects of designing which may not have been open to the researcher had an action research methodology been used. By taking a theoretical, human communication needs-centred approach the researcher has aimed to avoid the technological determinism which has influenced the development of many commercial investigations. However, in contrast to this theoretical foundation, the second phase of the research was interested in testing out the validity of the communication model by using current work in the field. The next chapter presents the results from the first phase of the research.

CHAPTER 5.0: RESULTS FROM PHASE ONE

This chapter will document the process and analysis and present the findings of phase one of the research (As illustrated in Figure 19). To achieve this it will be broken down into: literature review classification and assumptions; preliminary case studies; preliminary communication models and the BT expert forum.

5.1 Literature Review Classification

As an outcome of the literature review, a set of contextual assumptions was developed to indicate the standpoint of the research (as listed in Section 2.9) namely:

- Perception is creative, based on mental models of learnt signs
- The physical world shapes 'language'
- 'Language' alters the way we perceive the world
- The reader not the author produces the meanings from a message
- We have a range of different languages at our disposal
- The form of each language alters the way meaning is conveyed
- New technology has facilitated the development of a new three dimensional medium
- Three dimensional media have specific identifiable attributes.

In addition to this, a tentative list of topics and a grouping of critical issues was produced as shown in Table 8. This formed five key areas namely: aesthetic or representational issues, interaction issues, communication issues, user issues and design issues. This structure was further refined and used to organise the findings from the expert forum according to the literature review template in Table 5, following which it was developed into a set of questions to be asked of the secondary case studies.

Aesthetic Issues	Communication Issues
Iconography and modes of representation, icon, index, symbol Use of metaphor Realism – abstraction model Metaphor and genre Sound Animation	Modes of engagement / learning according to Brunner (enactive, iconic, symbolic) Convention VR as a language The role of context and venue Coherence and consistency
Interaction Issues Interaction (linear versus non linear interaction/user defined) Authorship versus Creatorship Narrative Navigation, including fly through Direct manipulation and feedback Mental Models User-centred interaction	**User Issues** Presence Collaboration in VR User centred design process Participatory Design **Design Issues** Design process is missing in much development of VR

Table 8: Key Topics from the Literature Review.

5.2 Overview of the Primary Case Studies

Two phases of case studies were researched, with the three early case studies being: Sculptural Metamorphosis, a degree project by the researcher; Knowledge=Power a CD Rom developed by Octo Design, and Emotional Icons, a VR project from British Telecom. These projects were selected according to the case study criteria listed in the methodology Section 4.5.4.1. In particular, they were examples where three dimensional imagery was used as the primary means to communicate using computers. This phase was intended to investigate early hypotheses, to identify critical issues and to highlight suitable questions to be asked of the secondary case studies. The phase was formative, with the findings providing a more robust basis for the second phase case studies. Unlike the second phase case studies, these examples did not involve formal interviews and were predominantly based on a reflection on previous practice by the researcher. In addition to personal reflection, the researcher reviewed project documentation, such as project briefs, and undertook informal discussions with the design practitioners at Octo Design and BT. The early cases were therefore used to identify quickly the scope for the later investigation and to review early findings from the literature review prior to the BT expert forum. What follows is a summary of each case study.

5.3 Sculptural Metamorphosis Case Study

5.3.1 Description of Nature and Aims and Objectives of the Original Project

The Sculptural Metamorphosis project's aim was: "To create a visual representation of a part of our world, a colourful three dimensional object where semiotics are essential in presenting ideas, themes, feelings or message." It was decided to visualise in three dimensions an individual's educational and vocational certification (See Figure 23), as it was felt the current medium of 'text' in the form of grades was insufficient for demonstrating the information. This was considered to be mainly due to the limitations of words to describe complex interrelated information due to the medium's linearity. An individual's education was considered to be a complex interrelated set of skills and achievements and it was felt that by visualising this complex interplay of factors. The aim was to enable the individual to reflect upon, question, or potentially change their values and opinions.

5.3.2 How it was Undertaken

Information about an individual's educational achievements was converted from textual 'grades' into a three dimensional form, creating a three-dimensional sculpture using industrial design model making techniques (See Figure 24). The three dimensionality of the sculpture would highlight both strengths and weaknesses of an individual, giving a better understanding of the effect of an individual's daily actions. Three dimensional computer visualisation techniques, using Alias | Wavefront software were used to create an animated visualisation (See Figure 25). This enabled additional aspects of the sculpture's functionality to be communicated by a multimedia presentation, using hypertext links to 'anchor' the abstract aspects of the sculpture's form to the more traditional (and therefore translatable) media of text, diagrams and pictures. The relative flexibility of the computer environment compared to the constraints of real world three-dimensionality offered an additional opportunity to change the form easily (animating growth over time), thereby enabling new meanings to be conveyed.

5.3.3 Outcomes from the Original Project

The project communicated a richer set of information than would have been possible through the traditional medium of words. It was found that changing media enabled the relationship of information to be emphasised through the interplay of the three dimensional structure. It was also felt that the three dimensional form conveyed the ideas more intuitively by cultivating immediate recognition of form and meaning through real world experience. In this way, meanings from other real-world experiences were integrated and emphasised in the design of the sculpture. Such aspects included using size (to represent the amount of achievement - larger sculptures show a more advanced level of education), different legs showing different skills (the skills being taken from research at Harvard looking at a broader range of skills than those which are currently measured in education[275]) and stripes to represent achievements in relation to a particular time span (as rings on a tree can demonstrate time and events such as weather).

5.3.4 Reflection and Interpretation

The project demonstrated the implications of choice of medium, highlighting the effect this has on the message. Although the use of computer visualisation was not primarily the aim of the project, this medium enabled the information to be conveyed in new ways. This led partly to the realisation that the computer environment could not only support some of the meanings attached to real world three dimensionality, but could also extend these in new, as yet unknown ways. Insight was gained with regard to the value of three-dimensionality in HCI especially relating to the demonstration of interrelated, complex and non-linear information. However, the project did have limitations, primarily the abstract nature of the form, which was not immediately recognisable within the current semantic system of classification (thus requiring the reader to form a new paradigm). This raised the issue of convention constraining the development of meaning.

[275] The concept "That intelligence (or ability) has at least seven different forms which do not necessarily correlate with each other. In concentrating on analytic intelligence as measured by IQ tests, we have down-graded the rest." As proposed by Gardner, H. Frames of Mind. In: Handy, C. *Understanding Organisations.* 4th ed., Penguin, 1993, p.239.

'Education' represented using text – A, B, C etc.

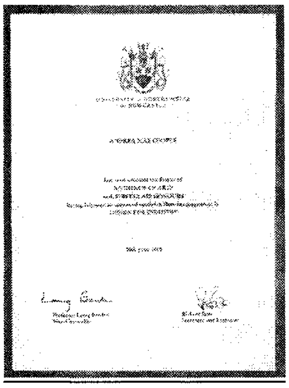

Figure 23: Exam Certificate Demonstrating Linear Text.

'Education' represented as a 3D Physical Model

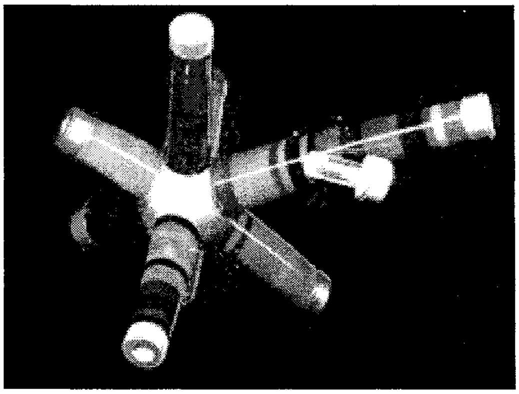

Figure 24: 'Sculptural Metamorphosis' 3D Physical Model.

'Education' represented as a 3D Animation

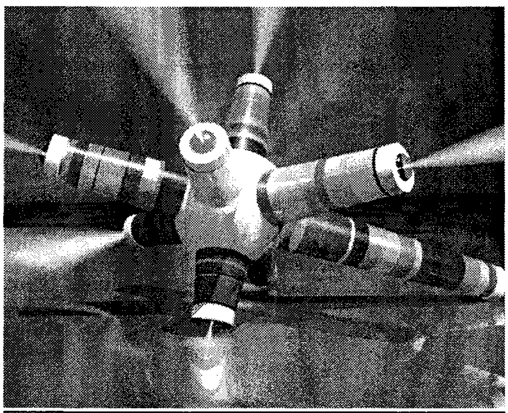

Figure 25: 'Sculptural Metamorphosis' 3D Digital Animation.

5.4 Knowledge = Power Case Study

5.4.1 Description of Nature and Aims and Objectives of the Original Project

Knowledge=Power is a multimedia publishing and consulting business, set up in 1995 by Kevin Gavaghan, Dr Tim Gibson, and Tim De Vere Green. The group appointed Octo Design in Newcastle to design and visualise a virtual learning environment, for which Tim Neill Associates created the software coding. As a freelance designer the researcher attended the brainstorming and development meetings, guiding the project on interface design issues.

The first multimedia title to be created by Knowledge=Power was a CD-ROM for the financial industry. The original aim of this project was to create a user interface for training purposes, using real world representations to convey meanings, rather than using the desktop computer metaphor. It was suggested that there were to be no drop-down menus or windows conveying information, but that the environment would represent a familiar three-dimensional space. As Tim Gibson suggested:

> "We have set ourselves the design goal that our interface shouldn't contain any of the conventional computer metaphors, such as windows, icons, menus, etc. There will be navigational cues but these will be in the form of real world objects."[276]

The typical user was considered to be primarily male and in their 40s and to have little or no previous computer experience. This profile was felt to be important to the choice of design content and the aesthetic of the space.[277] The following design principles, developed by the client Tim Gibson, formed the initial brief:

"- Provide as familiar and comforting an environment as possible.
- Use real-world metaphors wherever possible.
- Minimise the use of windows, menus, navigation bars, etc.
- Provide shortcuts.
- Don't let users 'lose' the objects they interact with.
- The content should constrain the interface, not vice versa.
- Keep everything modular."[278]

[276] Technical footnotes, alpha narrative, v1.02, TRG: Knowledge=Power, February 1996.
[277] Octo Design Brief, 2nd February, 1996, p.2
[278] Knowledge Direct, December, 1995.

5.4.2 How it was Undertaken

The primary metaphor for the design of the environment was a 'virtual learning centre', VLC^{TM}, which contained five rooms arranged around a central 'classroom' as shown in Figure 26. Within the space, real-world objects (such as chairs, tables, projectors, books, etc.) provided the ambience of a learning environment and guided users actions based on real-world experience. Two main themes were used for navigation and interaction; firstly, lighting in each room was used to highlight objects which might be interacted with and, secondly, each object was animated to draw the user's attention.

5.4.3 Outcomes from the Original Project

The VLC^{TM} was considered to be a successful metaphor for conveying a variety of information in an interesting and interactive manner. This success has been endorsed by The Midland Bank, Anderson Consulting, Allied Dunbar and IBM, who worked with Knowledge=Power in developing further CD-ROM titles. The project featured in *Design Week's* First Sight section, a copy of which can be found in Appendix 9.

5.4.4 Reflection and Interpretation

The project contributed to the researcher's increased understanding of the concept of mimesis,[279] which describes the heavily reflective nature of many current interfaces' appearance. It was felt that this formed a constraint on the interface if used literally, especially when real-world objects were used, even though better forms of representation existed. For example, the use of a virtual laptop in the VLC^{TM} Library was felt to contradict the original aim to provide an interface which non-computer users could understand (See Figure 27). The research concluded that when real-world metaphors were used it was important that the metaphor should apply across the board, have logic to its real-world counterpart and not constrain the potential development of the medium.

[279] Laurel, B. *Computers as Theatre.* Addison-Wesley Publishing Company, 1993, p.45.

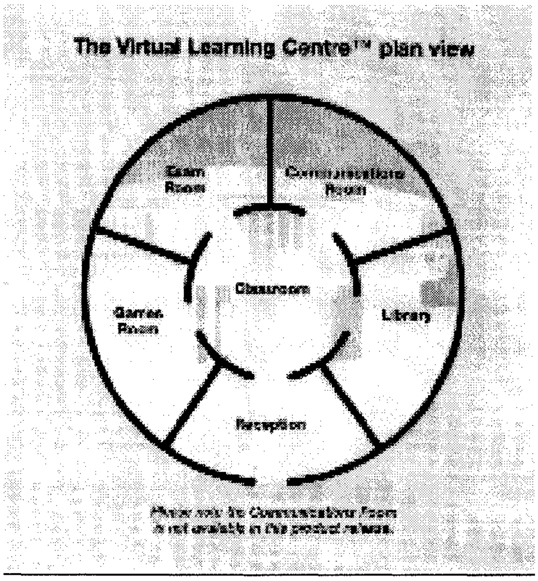

Figure 26: Knowledge=Power Case Study: Overall Space Plan.

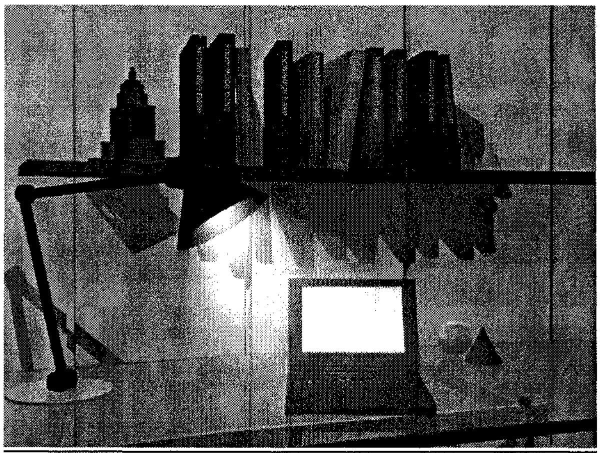

Figure 27: Knowledge=Power Case Study: Library, Featuring Computer Metaphor.

5.5 Emotional Icon Case Study

5.5.1 Description of Nature and Aims and Objectives of the Original Project

The Emotional Icons project was undertaken as a joint investigation between Staffordshire Polytechnic and BT. The basic premise of the research was summarised by a quotation which featured throughout the documentation: "Things that are easy to use get used." It was felt that a more intuitive interface would enhance the quality and usability of BT's products and services. As noted in the project documentation:

> "The objective of this study is to develop an understanding of the intuitive processes, clues and steers that we derive from our everyday environment and then to apply these to a telecoms user interface which would represent an environment reflecting the world in which we work. It will be focused on an alternative way to understand, visualise and control complex and changing data, as found in network management tools, databases and home and business telecoms services."[280]

5.5.2 How it was Undertaken

The concept used three dimensional imagery, animation and sound to convey messages in a virtual environment. It formed two distinct phases, where the initial work by Staffordshire Polytechnic looked at simple animations of form using storyboards to create a cartoon sequence. The second phase, undertaken by BT, implemented and developed the findings using computer modelling techniques. This work concentrated on creating a series of 'icons' that conveyed meaning by using representations which expressed emotion through movement and form. Five main icons were created (four featured in Figure 28), which represented their functions by attributing the following emotions: shy, aggressive, defensive, disappearing and nervous. The icons could react to the user based on their relevance to the task at hand, using intelligent data searching and task scheduling software.

[280] From Case Study documentation obtained at BT during induction period. Emotional Icons PPD Issue 1. 29 Sept 1993.

5.5.3 Outcomes from the Original Project

The project was felt to be successful by the design team in terms of its initial objectives. The three-dimensional representations illustrated information that was inherently complex in a manner which was more immediately discernable, comprehensive and intuitive to a range of people. This was highlighted in an article in *British Telecommunications Engineering*:

> "The project was taken to the 1994 Edinburgh Festival as part of an exhibition that attracted over 10,000 visitors. Many of them tried the system including very young children, elderly people and those who spoke only a little English. Their actions and comments suggested that they readily understood the emotional icons."[281]

It was felt that these and similar tests demonstrated the potential of emotional icons for enhancing the usability of complex information systems. The project was consequently subsumed into a new project called 'Smart Desk'[282] which was a hardware and software interface for dealing rooms (see Section 6.3). The emotional icons project was felt to be indicative of the kind of representations of complex numerical information that might appear on such an interface. The service provider for the current dealing rooms, Syntegra, was involved in the development of the interface, from which an entirely new project has developed.

5.5.4 Reflection and Interpretation

The project was based on a narrow empirical approach, from which the 'icons' evolved through trial and error. This process caused the icons to be significantly formed by the capabilities and limitations of the software (Superscape), together with the combined experience of the human factors department. The work formed a heuristic approach which was often unaware of the previous theoretical work in communication studies. Through this case study, the research programme has gained new insight into the use of three dimensional representations in HCI, especially relating to the presentation of complex information whose change in form is significant to our understanding of it, as well as revealing relationships, and conveying non-linear information.

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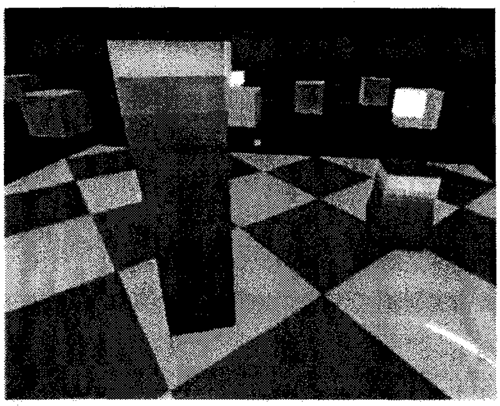
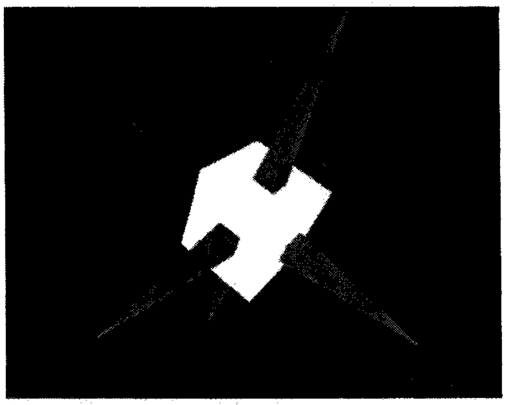
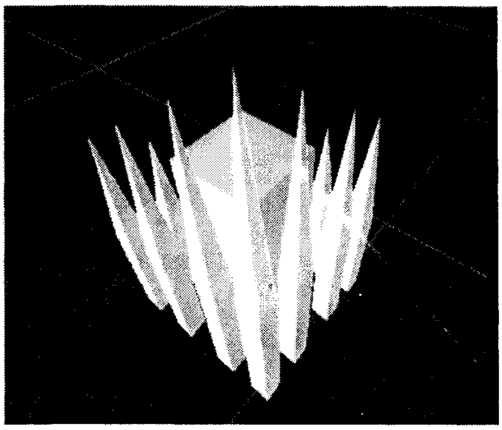
[281] Fisher, K. et al., Non-Verbal Guidance for Cyberspace Explorers. *British Telecommunications Engineering,* 14 (2), July 1995, p.131.



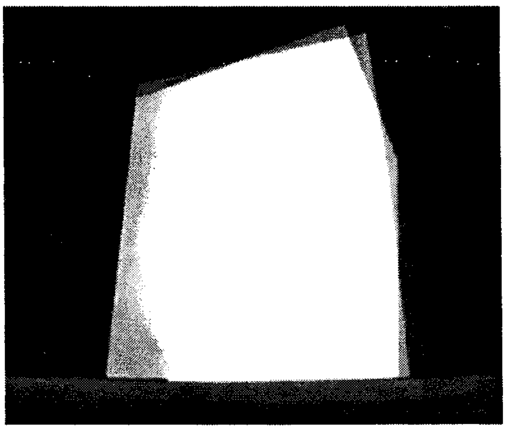
Shy Icons



Defensive Icon



Protected Icon



Nervous Icon

Figure 28: BT Emotional Icons Project, 1992.

5.6 Other Case Studies Investigated

Various other projects and CD-ROMs were looked at to provide a broader background to the investigation including Multimedia 96 and Artifice. Such work served to provide additional examples-of state-of-the-art interaction design, however it was not suitable for full case study analysis, as it did not represent appropriate three-dimensionality.

[282] Smart Desk Video, Syntegra.

5.7 Analysis of the Primary Case Studies

5.7.1 Findings from the Work Completed

The principle conclusion of the primary case study phase of the research programme was the development of tentative communication models that demonstrated different representations' generic virtues and constraints. Secondary issues which were felt to be important were the relationship between the designer and the audience (the reader), the role of convention and the difficulty of transcending media types.

5.7.2 Communication Model Demonstrating Media Virtues

A number of communication models were developed from findings of the case studies and literature search that included findings from work by Fiske, Saussure and Pierce. The first model (Model A) looked at demonstrating different ways of representing the same concept as illustrated in Figure 29:

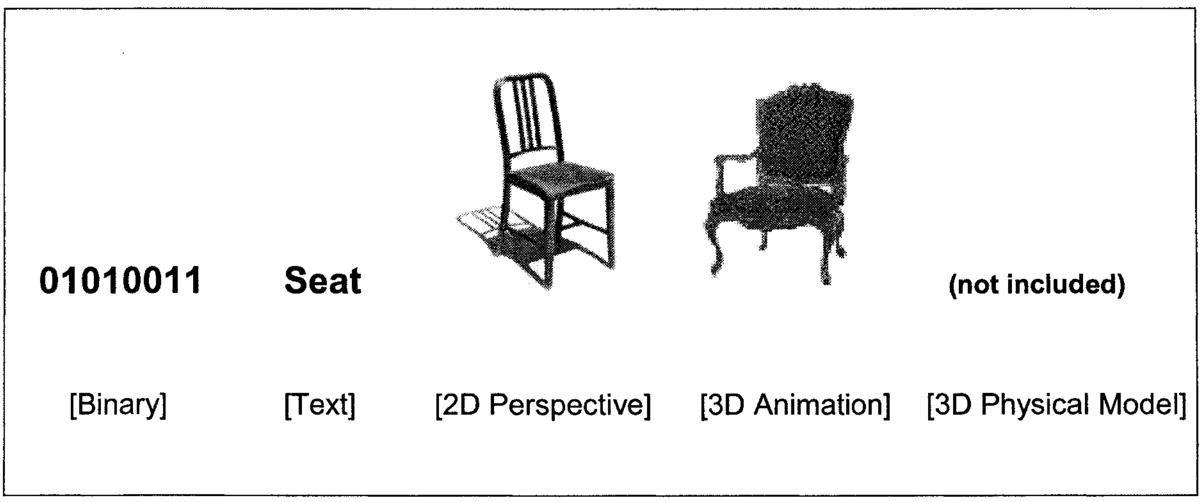


Figure 29: Communication Model A: Different Media Expressing the 'Seat' Concept.

Five types of representation (four shown above) were used to represent a commonplace real-world object such as a seat. At this stage the model used a dolls house seat to exemplify the three-dimensional representation (not included). This model was then developed further to include a representation of the user, reader and channels of communication, as shown in Figure 30.

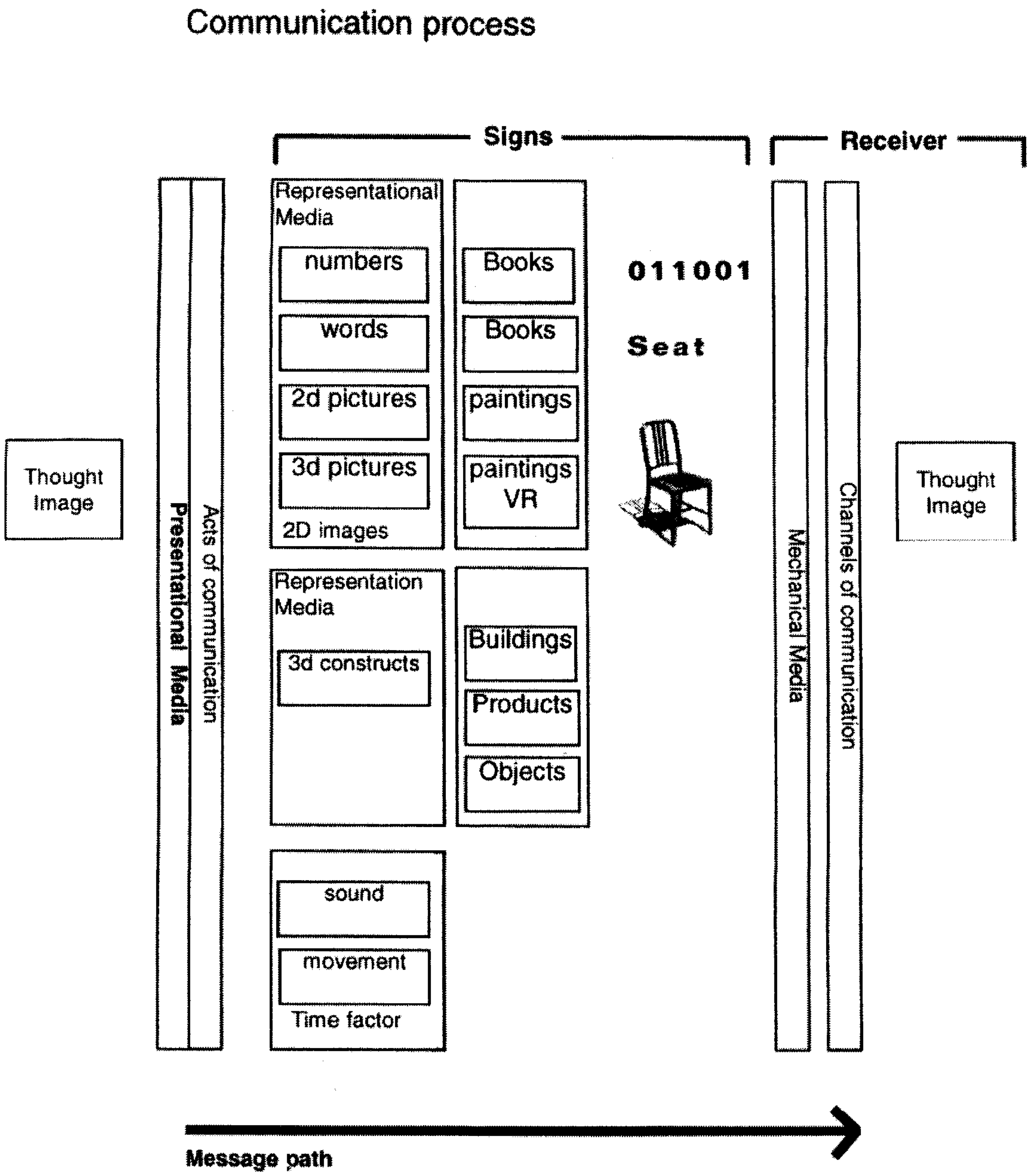


Figure 30: Communication Model B: Showing Audience Relationship.

Each form of representation was felt to have its own unique virtues. Communication model C aimed to suggest tentatively what these might be as shown in Figure 31:

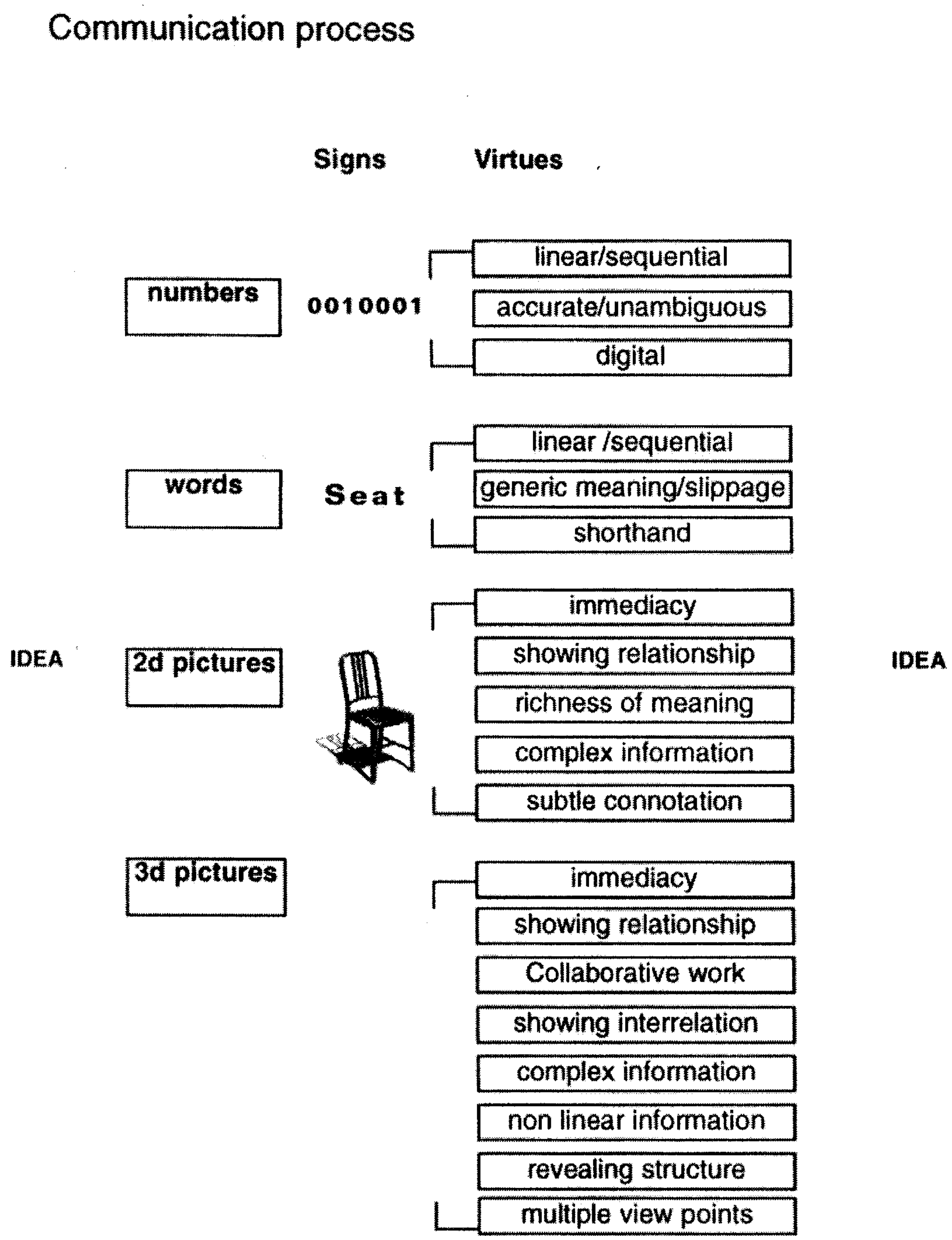


Figure 31: Communication Model C: Illustrating Tentative Media Virtues.

5.7.3 Role of Audience/Designer/Context

Alongside these models, Pierce's communication model[283] was used to describe the relationship of the sign, the thing it represents and the reader's idea of it. Pierce suggests a tripartite relation of sign. This assumes that the sign exists separately from our interpretation of it (see 2.5.1 for discussion), therefore, different people can read the same sign differently based on their experience. This results in individuals developing their own lexicon and is referred to by Pierce when he suggests the sign can create "an equivalent sign, or perhaps a more developed sign."[284]

By combining an understanding of audience with sign and the media of communication (as interpreted from Fiske), the next model focused on resolving the relationship between these factors. In this illustration four viewpoints are represented as four different spheres, they all face the same object shown in the middle (as a blue cone), yet the 'glass' (their interpretant) prevents them from all 'seeing' the same thing. A set of 3D Communication models was created as a mental model for understanding audience and modes of representation as shown in Figure 32.

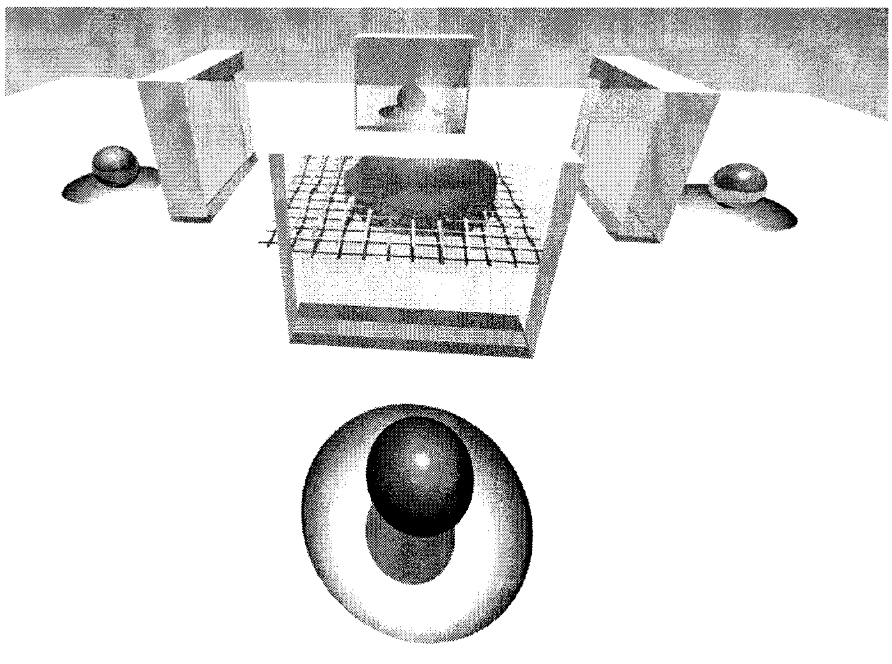


Figure 32: 3D Communication Model Showing Four 'Viewpoints'

[283] Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.42.

[284] Zeman, J. 'Peirce's Theory of Signs' In: Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.42.

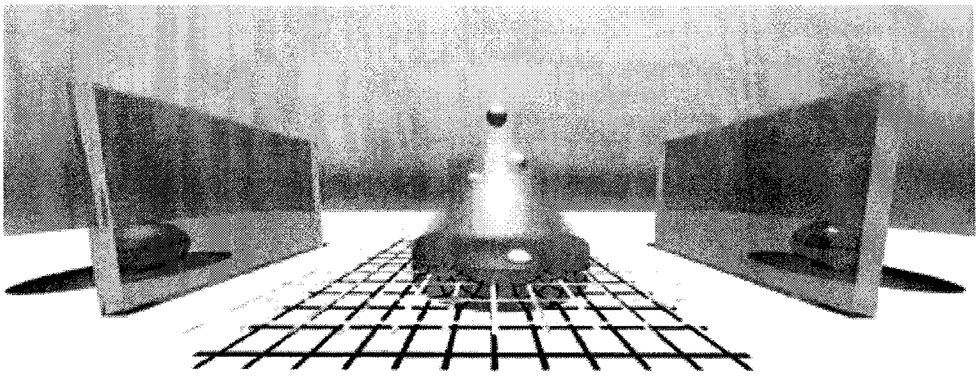


Figure 33: 3D Communication Model Showing Item Being Viewed.

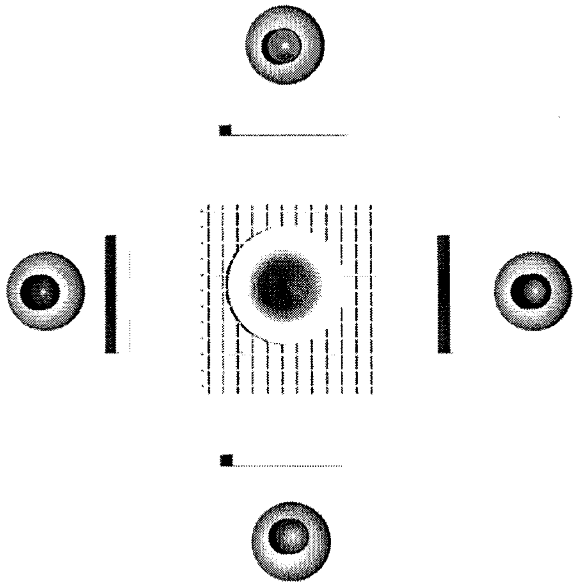


Figure 34: Plan View of 3D Communication Model Showing Audience and Representation.

During the development of communication concepts the designer was considered to act as the reader. Here, the designer acts as the interpreter of the sign on behalf of a chosen audience. It was felt that most designers perform this role naturally as a consequence of them actually being a member of the intended audience. In such instances the designer often ends up designing for themselves. It was felt that if the different interpretants could be more apparent (alternative readings), the designer could more sympathetically and accurately represent the desired audience.

5.7.4 Methodology for Testing and Validation of the Model

The primary communication models were presented at a number of events including visits to BT, which were undertaken to review the models with other experts including Phil Smythe. Additionally, the Knowledge = Power case study work was published in the 'First Sight' section of *Design Week* (See Appendix 9 for the article). More formally, the research project arranged an expert peer review event to look at the issues raised and review the model. This will be covered in the next section.

5.8 BT Expert Forum – Media and Contextual Issues

An expert forum entitled 'Visualising the Future' was held to consider the broad theoretical issues surrounding the development of the three-dimensional medium and to review the findings of the early case studies. The group was arranged to look at issues of representation in VR, in particular the use of three dimensional images. This forum was held at the Human Factors Department at BT Labs, now called Adastral Park, in Ipswich. A number of specialists were involved, representing the disciplines of psychology, human-computer interface design, semiotics, communication studies and design. The aim of the forum was to contextualise the research by using key experts in the field to tackle a range of questions on the future development of three-dimensional media and VR and to review the early communication models.

5.8.1 Panel Members

Speakers from a variety of disciplines were invited including psychology, semiotics, human factors, computing, design, multimedia and communication studies. The experts who attended the event, their organisation and expertise are listed in Table 9.

Individual	Organisation	Expertise
Professor Robin Baker (Chair)	Ravensbourne College	Design, Computing
Professor Gunther Kress	University College London	Visual Design & Semiotics
Greg Rowland	Semiotic Solutions	Culture, Communications & Semiotics
Professor Harold Thimbleby	Middlesex University	Computing and psychology
Professor Martin Woolley	Goldsmiths College	Design
Professor Kevin Robins	Newcastle University	Visual culture
Kim Fisher	BT Laboratories	Design, Human Factors and Futures
Organisers		
Andrea Cooper	Northumbria University	Researcher
Dr Robert Young	Northumbria University	Director of Studies

Table 9: BT Expert Forum Contributors.

Professor Robin Baker was chosen to chair the event because of his design and computing background and to allow the discussion to flow around broad issues, but to maintain a focus within the remit of design and the designer. Kevin Robins was unavailable to attend the event, yet was interviewed prior to the day to convey the ideas and to gain an insight into his cultural and technological standpoint. The combined list of potential experts was constructed with the realisation that some members would be unavailable. The final list of attendees was considered suitably representative of the breadth of knowledge necessary to obtain valid findings. A number of alternative participants were discussed and contacted, however they were unavailable on the day of the event. They are listed in Table 10:

Individual	Organisation	Expertise
John Fiske	University of Wisconsin	Communication Studies
Umberto Eco	Bologna University	Semiotics
Malcom Evans	Semiotics Solutions	Semiotics
Peter Cochrane	BT Laboratories	Future Analysis

Table 10: BT Expert Forum Additional Invitees.

5.8.2 A Summary of the Event

The forum was held at BT Labs in Martlesham Heath, Ipswich. A room was arranged within the Human Factors Department with telephone conferencing and multi-camera video recording technologies. Speakers received a document in advance highlighting the research to date and showing the communication models, as well as describing the aims and objectives of the forum. Additionally a visit was made to Semiotic Solutions in London to run through the presentation in advance of the event for feedback and minor adjustments. The researcher remained an objective observer, whose role was to introduce the day and record the proceedings. Other organisers included Dr Robert Young and Kim Fisher. Dr Young took part from Newcastle via telephone conference and remained objective, recording notes on the event. In contrast, Kim Fisher, an expert on VR and Design Futures, was an active participant in the debate.

A Powerpoint presentation was created which highlighted the issues addressed by the research.[285] This presentation was intended to focus the discussion and if necessary add any additional areas of interest to the debate. To maintain the objectivity of the process, the presentation did not represent any findings, but it did reveal the assumptions upon which the research was being undertaken. These would fall roughly into two categories - research assumptions and research questions. The speakers were asked initially to put forward their own positional statements to introduce their viewpoint. This was followed by a general discussion of the issues.

5.8.3 Research Assumptions

The research assumptions represented the explicit choices made by the researcher that allowed the subject matter to be defined and the questions to be raised. These were initially explained using examples and references in the presentation. The unordered list of the contextual assumptions can be found in Section 5.1.

5.8.4 Research Questions

The research questions were generated by the researcher at the start of the project to address the research objectives (as noted in Section 1.4.2). These were exploratory and descriptive questions based on what, and how modes of enquiry. These address the objectives as follows:

Objective 1: (Q2) - What might its benefits/constraints be?
Objective 2: (Q3) – How can we use an understanding of other media to gain an insight into what Virtual Reality has to offer?

For the expert forum these questions were further refined from the literature review and sought to establish consistent terms amongst the experts (Q1), to ensure the event investigated a breadth of issues (Q4&5), and to consider future possibilities (Q6&7).

[285] A full transcription of the contents of the presentation can be found in Appendix 6.

The research questions were formulated to focus the discussion and related to the kinds of questions the research had addressed. The list of the questions raised included:

1. What is the three dimensional medium?
2. What might its benefits/constraints be?
3. How can we use an understanding of other media to gain insight into what Virtual Reality has to offer?
4. What contextual issues surround this new medium?
5. Will it open up new knowledge?
6. What are the implications of not addressing this?
7. How should this issue be pursued in the future?

5.8.5 Data Collection and Treatment

A video recording was made and shorthand notes were taken during the event by the researcher. The completed notes were subsequently disseminated to the speakers for comment or reflection. Many themes emerged on the day, specifically in relation to the cultural, economic and technological context for the development of the three-dimensional medium. Under the direction of the experts, the researcher recorded a formative list of issues and questions. This formed the conclusion to the main discussion at the end of the event. This was considered to reflect the main issues from the entire day's discussions.

The treatment of the data was undertaken as a process of filtration of themes and questions. The speakers were invited to note their own findings and send them to the researcher to cross reference. Two experts forwarded their synopsis and further interpretation: Martin Woolley and Robin Baker (The full set of their notes can be found in Appendix 5). The findings were then presented on a website prepared for the research (http:vision.unn.ac.uk/ion/visualise).

5.8.6 Key Findings from the Expert Forum

In addition to testing the model and assumptions to date, the key findings from the event represented the philosophical and intellectual viewpoint of experts in the field. This peer review and data gathering was seen as a further refinement of the research assumptions and formative conclusions. Details of the issues and dilemmas raised are represented in the next section.

5.8.7 Issues and Dilemmas

The following list of untreated data was produced on the day by the expert group.

- The relationship between epistemology and systems of representation.
- Referential transparency - Can a sign stand for a reality so well that we cannot distinguish between the two?
- Where do the media stop – where are the edges?
- Interaction, as a core phenomenon - what is the new part of it? What is the core functionality?
- Are the affordances hidden - what are they?
- What is the relationship between 3D and 4D media - the fourth-dimension gives the opportunity to 'travel' – explore / revisit? Travel in time?
- What are the implications of Western metaphors of space?
- What is the potential of a self-generated narrative?
- The role of three-dimensional media within culture: realism through to symbolism?
- What are the ways into the medium?
- The 3D brand? What is it, what do you fill it with?
- Relation to 'land' the consideration of 3D media as a commodity. How to divide it - 'semiotic/cultural'?
- There appear to be both utopian and market-driven visions about the potential of the medium.
- The utopian view is necessary.
- What is the relationship between 'reality' and the 3D virtual?
- Ethical frameworks - no longer 'personal' constraints.
- What are the consequences of actions in the virtual?

These issues were classified according to the literature review findings (as discussed in Section 2.9) and augmented with the extra comments received from the attendees after the event. A categorised list can be seen in Table 11.

Issue Classification		Results
Representational Issues	**-Metaphor (genre)** -realism/abstraction -dimensionality	• The relationship between epistemology and systems of representation. • What is the relationship between 'reality' and the 3D virtual? • Referential transparency – Can a sign stand for a reality so well that we cannot distinguish between the two? • The role of three-dimensional media within culture: realism through to symbolism?
	-visual content -audio content -haptics -olfactory -time / animation	• What is the relationship between 3D and 4D media – the fourth-dimension gives the opportunity to 'travel' – explore / revisit? Travel in time?
Interaction Issues	**Narrative** -travel or way finding -action/education/ experience	• What is the potential of a self-generated narrative? • The 3D brand? What is it, what do you fill it with?
	Navigation -mental model -spatial issues	• What are the consequences of actions in the virtual? • What are the implications of Western metaphors of space?
	Presence -immersion -kinaesthetic	• Where does the media stop – where are the edges?
Usability	**Conventions**	• Relation to 'land' the consideration of 3D media as a commodity. How to divide it – 'semiotic/cultural'?
	Users -engagement -user-centred design	• Interaction, as a core phenomenon – what is the new part of it? What is the core functionality? • Ethical frameworks – no longer 'personal' constraints.
Design Issues	**Other Design issues**	• The utopian view is necessary to develop practice.
	The medium -technologies -Pros / Cons	• Are the affordances hidden – what are they? • What are the ways into the medium? • There appear to be both utopian and market visions about the potential of the medium.

Table 11: Results of the BT Expert Forum (Categorised).

5.9 Conclusion from Research Phase One

The conclusion of the primary phase of the research was the identification of a number of communication models (Figures 29, 30 and 31). In particular, Figure 31 demonstrated different representations' generic virtues and constraints. Such virtues included information that is inherently complex in nature such as the visualisation of:

- Collaborative work
- Complicated or voluminous information
- Information whose change in form is significant to our understanding of it
- Information which needs to be assimilated quickly
- Information which is non-linear, e.g. hyperlinks
- Revealing structure
- Relationships between entities or individuals (especially with regard to various vantage points for the viewer (reader).

The secondary issues which were felt to be important were; the relationship between the designer and the audience (the reader), the role of convention, and the difficulty of transcending media types. Additionally, across cases the interface was considered to be intuitive to a range of people.

5.10 Implications of the Findings

It was considered that the models highlighted many of the issues involved in communication studies in a manner that would be accessible to the designer, demonstrating the interrelation of the factors involved. It also provided a descriptive framework within which the unique virtues of three-dimensional images might be considered. The anticipation was that the model could be further developed as:

- A tool for investigating the key issues (mapping the territory, use of terminology)
- An indicator of the cause and effect relation (strategic planning and evaluation tool)
- A means to unlock and relock a process of planning and reflection within a spiral of development.

These considerations, combined with the outcome of the literature review, formed the basis for the analysis of secondary case studies. The outcome of this phase was the development of further case study criteria for selection (see Section 4.5.4.2 Criteria for Secondary Case Study Selection) as well as a structure for the interviews and analysis of the next phase of work.

CHAPTER 6.0 RESULTS FROM PHASE TWO

This chapter will describe the findings from the secondary case studies and introduce the methodology for the validation of the primary and secondary communication models. To achieve this it will be broken down into three main sections: secondary case studies; secondary communication models and review through an expert colloquium.

6.1 Overview of the Secondary Case Studies

The second phase case studies included Call Waiting, Smart Desk Concept 2010 and 3D Retail. These projects were developed in BT's Human Factors department and were visualised using VR software. This phase built on the findings from the primary case studies using a refined set of criteria for the selection of cases (see Section 4.5.4.2) as well as a more structured analysis technique through an issue framework. The case studies were analysed by studying the effectiveness of metaphor, navigation, kinesics[286] in terms of clarity and richness of communication. Subordinate to these criteria were functional issues including immediacy of feedback, visual qualities (aesthetics), sonic qualities and kinaesthetics. The case studies employed multiple sources of data with the researcher acting as an objective reviewer of the work during a six-month internship at BT's Labs (see Section 4.5 for a full discussion of the method). This phase was summative with the findings contributing directly to the formation of a final model of communication.

The Call Waiting project used abstract and iconic metaphors to create concrete mental models for the users to understand call processes. Call Waiting was also a pilot case study and as a consequence of the first interview minor suggestions for improvement in method and technique were integrated into the process. The second case study was Smart Desk, Concept 2010, a banking modelling project for Syntegra, which provided functionality analysis of software systems. It was an extension of the work on Emotional Icons and Smart Desk, looking at visualising numerical data with live feed graphics (from Excel to Superscape). Finally, 3D Retail was a three dimensional interface for shopping over the internet. This project had a complex user interface which combined 2D and 3D information where necessary.

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[286] Grimes, J. Issues in Multimedia publication. In: Owen, C.L. (ed.) *Design Processes Newsletter*, 4(6), 1992.

6.2 Call Waiting Case Study

Call Waiting was a visualisation of the 'call waiting' function of a telephone exchange as experienced by a telephone user. The concept was to design an animation in VR which could take users through the call waiting process step by step, enabling them to learn the system. The main problem with the existing system was that call waiting required users to key into their telephone a set of commands which were difficult to remember. As the telephone's numeric keypad did not directly show information about how to operate the service, users usually needed to read a lengthy manual in order to work the system. It was felt that users lacked a 'mental model' of the operation of the system against which to decide what actions needed taking. A VR visualisation of the system was developed to provide this mental model and potentially remove the need for the manual.

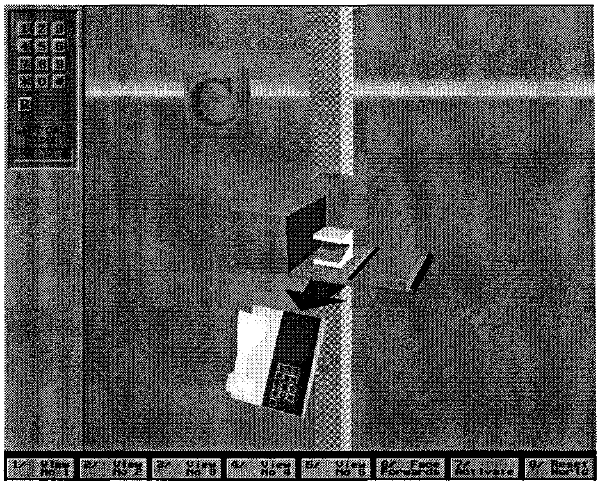

Figure 35: 'Call Waiting' Case Study Screen Shot.

In the visualisation, a telephone call is represented as a bouncing cube with an open mouth (centre of Figure 35) which animates, as though it is talking, when in use. This object can be moved between different locations, allowing the user to explore ways of putting a call on hold and subsequently retrieving it. As a visualisation it was unusual to represent a message as an object rather than a connection between two points.[287] The cube would bounce when on hold and become more agitated, bouncing more frequently over time to indicate how long the call had been waiting.

[287] Durrell Bishop at the Royal College of Art had created an answer machine which put messages on objects, where a marble represented a call.

6.2.1. Description of Nature and Aims and Objectives of the Original Work

The work originated from a large project within BT focused on providing 'service creation tool improvements'. As Kim Fisher suggests:

> "This Call Waiting was a hard problem, they had got a visualisation tool for creating services and it was massively complicated and it needed a lot of learning to be able to use it, and they thought that what we were doing would be able to make it simple."[288]

The aim of the work undertaken within Human Factors was "to explore a possibility of 3D data visualisation"[289] to simplify and make the information more readily usable. Call Waiting in particular was also later to cover additional issues, specifically mental modelling.[290]

6.2.2 How it was Undertaken

Three main people were involved, two from BT and one from Superscape.[291] The interface was created using what was then state-of-the-art PC Virtual Reality software 'Superscape' version 2.5 running inside DOS. As Fisher notes: "At that time it was the state-of-the-art it is still state-of-the-art but it's on version 5.5, it runs inside Windows 95, but it doesn't run any faster than it used to."[292] The interface was created as a service generation toolkit, allowing users to transform 3D information into code that acted like 'Lego parts' which could be constructed by the end user. The system uses abstract and iconic metaphors to create concrete mental models for the users to understand 'call processes'. It was hoped that in terms of ease of use the interface could be favourably compared with the traditional way of explaining the service through a text-based instruction booklet.

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[288] Case Study Analysis - Call Waiting Q7a 'Justification', Appendix 3, p.22.

[289] Case Study Analysis - Call Waiting Q8a 'Project Aims and Objectives', Appendix 3, p.23.

[290] Mental Modelling of Network Services "This is a method of using 3D objects, with certain characteristics and attributes, to build virtual models of how Network Services operate and can be configured from a customer's perspective." Emotional Icons and a Virtual World User Interface 070295, p.11 (Emotional Icons/Call Waiting Research Document 13).

[291] Kim Fisher (BT), Amanda Oldroid (BT) & Brian Salt (Superscape) Case Study Analysis - Call Waiting Q14a 'People', Appendix 3, p.27.

[292] Case Study Analysis - Call Waiting Q19b 'Building the Virtual World', Appendix 3, p.36.

6.2.3 Key Findings from the Call Waiting Case Study

The case study material was analysed for critical issues which were placed in Table 12, according to the developing framework.

The semi-structured interview found that the key advantages of using 3D were considered to be the speed at which designers could generate animation[293] and the ability to set and re-adjust the viewpoint.[294] Additionally, the control of the visualisation by the designer was felt to be a benefit,[295] allowing a reduction in time from the idea to the final creation.[296] The main disadvantages of using 3D were the poorly designed, inconsistent tools for creating the worlds.[297]

In design terms, many of the visual and sonic elements featured in the final interface were created from clip art. As Kim Fisher notes: "...we didn't build anything specifically for this, the arrow came out of a library, the telephone came out of a library of objects it was just how it was configured."[298] This also had a bearing on the way objects functioned in the VE: "We can flash an arrow ever so easily whereas to get an arrow to move wasn't that easy. So we flashed the arrow."[299] Decisions also needed to be made about visualising concepts which didn't have a concrete real-world referent such as 'a call'. Once created such 'objects' were considered to be prone to Newtonian physics, such as gravity, and displayed properties of object permanence where they had to disappear in a believable manner.

Technological determinism was not considered to play a particularly prominent role in the conceptualisation of the worlds in that a key problem was not representing things but rather choosing *how* to represent concepts. Fisher notes: "It was the ideas not the tool that was the problem."[300]

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[293] Case Study Analysis - Call Waiting Q136 'What were the advantages of using 3D,' Appendix 3, p.64.
[294] Case Study Analysis - Call Waiting Q136 'What were the advantages of using 3D,' Appendix 3, p.64.
[295] Case Study Analysis - Call Waiting Q136'What were the advantages of using 3D,' Appendix 3, p.65.
[296] Case Study Analysis - Call Waiting Q136 'What were the advantages of using 3D,' Appendix 3, p.65.
[297] Case Study Analysis - Call Waiting Q138 'What were the disadvantages of using 3D,' Appendix 3, p.65.
[298] Case Study Analysis - Call Waiting Q65 'Visual Content.' Appendix 3, p.55.
[299] Case Study Analysis - Call Waiting Q33 'Did the software play a part in the design?' Appendix 3, p.41.
[300] Case Study Analysis - Call Waiting Q23 'Would it have been possible to create the virtual world using different software?' Q23b) If so, would this have changed the design? Appendix 3, p.38.

Additional conclusions can be drawn from documentation written about the work, in particular 'Emotional Icons and a Virtual World User Interface' which revealed the importance of navigation,[301] 3D sound,[302] consistency of use of emotional icons[303] and cross-cultural issues.[304] Also issues of realism were raised, in particular the use of photorealistic rendering.[305]

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301 Emotional Icons and a Virtual World User Interface 070295, p.13 (Emotional Icons/Call Waiting Research Document 13) "Navigation through data spaces in VR is critical to the successful use of networked and interactive information."

302 Emotional Icons and a Virtual World User Interface 070295, p.13 (Emotional Icons/Call Waiting Research Document 13) "The use of 3D sound can have significant effect on the ease of use."

303 Emotional Icons and a Virtual World User Interface 070295, p.13 (Emotional Icons/Call Waiting Research Document 13) "Emcons can be introduced into user interfaces but they must be structured and consistently applied."

304 Emotional Icons and a Virtual World User Interface 070295, p.13 (Emotional Icons/Call Waiting Research Document 13) "Anthropomorphising of objects, such as files with legs and smiles, should be avoided as involved numerous cross-cultural issues and limits globalisation. Use of apparent real-world artefacts in VR must be seriously scrutinised and applied with consideration..."

305 Emotional Icons and a Virtual World User Interface 070295, p.13 (Emotional Icons/Call Waiting Research Document 13) "The need for photorealistic rendering of objects in a Virtual World user interface is secondary to its intuitive interactivity, and visual and audio responsiveness. The more photorealistic a rendering is in the VR world then the more obvious the flaws. If objects remain uncomplicated in form and nature, and retain their attitude, then the mind will give them reality a la Walt Disney."

<table>
<tr><th colspan="2">Issue Classification</th><th>Results for Call Waiting</th></tr>
<tr><td rowspan="2">Representational Issues</td><td>Metaphor (genre)
-realism/abstraction
-dimensionality

-object permanence</td><td>• Emotional iconography was used where icons could have 'turned red and got angry'.
• Real-world attributes were used such as shrinking and 'dying away', gravity and resistance or 'slip'.
• 'Slip' was used on objects (like the talking cube) to add realism. Here the object slides across a surface. This 'reality reaction' made it seem like two objects rather than becoming part of the surface it was placed on.
• Breaking real-world conventions, calls (cubes) would 'disappear' when finished. This didn't work, so a call would fall through a trap door first and only disappear when out of view.
• Used real-world and conventional audio: for example a telephone 'ring' and cartoon sounds such as 'boing'.</td></tr>
<tr><td>-visual content
-audio content
-haptics
-olfactory
-time/ animation</td><td>• They didn't 'build' anything for it, the objects were from clip objects and were configured, apart from one item (a computer chip) which didn't have a clip object.
• Sounds used were 3D clip sounds.
• 'Sound was a shock because it was so powerful'. It was considered to be vital.
• Cartoon flashing arrows were used.</td></tr>
<tr><td rowspan="3">Interaction Issues</td><td>Narrative
-travel or way-finding
-action/education/ experience</td><td>• A logical sequential educational experience – mimicking the brochure.
• Things outside the field of view were inconsequential to the users in that where calls came from and went to didn't matter as long as they had a visible path in the field of view that led them beyond the frame.
• It was easier to build narrative from the iconic to the symbolic rather than the other way around.</td></tr>
<tr><td>Navigation
-mental model
-spatial issues
-scale</td><td>• Putting a telephone keypad in the 3D frame made it difficult to use so they replicated it in 2D on the surrounding frame.
• 'This is all about mental models'. A mental model doesn't have any bounds – 'It doesn't have a horizon or a position in your head'.
• Minimal movement in the 3D world.
• Users could change the viewpoint but had only limited navigational opportunities.
• 'Reset the world' function was useful.</td></tr>
<tr><td>Presence
-immersion
-kinaesthetic</td><td>• Screen based, Fish tank VR as it was easier to teach somebody or show to a group of people.
• No kinaesthetic.</td></tr>
</table>

Table 12: Summary of the Results from the Call Waiting Case Study.

Usability	**Conventions**	• It was felt people would not need to understand computer conventions. • Technically 'distancing' was used to speed the rendering.
	Users -engagement -user-centred design	• One model could be used to communicate to different users i.e. customer, sales people, service designer (all had a shared mental model). • "We have had an amazingly consistent reaction to it" by users.
Design Issues	**Other Design issues** -guidelines	• "How on earth do you represent a call? Was the biggest thing". • The team worked iteratively with a 'suck it and see' approach. • Emcons should be structured and consistently applied.
	The VR medium -technologies -pros / cons	*Pros:* • Once people saw the visualisation it became self-selling, it didn't need explaining. • Interactive. • Easier to create than animation, in particular speed of production, generating animation sequences in seconds. • More flexible to solve problems. • Control over viewpoint and the ability to change viewpoints. • Smaller file size than an equivalent animation. • The ability to animate a mental model. • It was used totally out of proportion to the time it took to create it. • Design control over the visualisation by the creator, rather than via a technician or programmer. • The ability to make lots of changes easily, therefore highly creative [to develop iteratively]. *Cons:* • Software tools poorly designed, inconsistent interface, difficult-to-use UI.
Technical Issues	**Software** **Hardware**	• Modelled in Superscape version 2.53. • The software was not felt to constrain the concepts "it was the ideas not the tool that was the problem". • Software did affect the design – the modelling had to be very basic to allow the machine to do quicker frames. This means you end up with a cube rather than a sphere for example. • They felt they didn't really fully utilise the 3D world in this project but rather used it as an animation tool. • Interface was using a space mouse.
Data	**Journals/Film/ Project files**	• Project File. • Two visualisations.

Table 12: Summary of the Results from the Call Waiting Case Study (continued).

6.3 Concept 2010 Case Study

Concept 2010 was a collection of technologies developed by BT and partners which were integrated into a concept for future financial trading rooms. At this time BT was a major player in this sector of communications, controlling 40% of the world trading room market,[306] with a 55% share in the UK market for dealing rooms technology. This is significantly distributed, with BT's technologies implemented in 1400 sites across 45 countries.[307] The project brought together state-of-the-art; data visualisation, displays, videoconferencing, spatial sound systems, infra-red wireless communications, speech recognition, speech synthesis (Laureate), talking head avatars, text summariser (Netsum) and security features in a singular, purpose-built systems furniture desking solution. BT worked with Syntegra, BT's System integration arm, as well as Specialised Banking Furniture International Ltd – SBFI (desk development), Edinburgh Communications Ltd (spatial sound), C-C-C (videoconferencing), Hitachi, Microvitec and Digital to develop the concept.

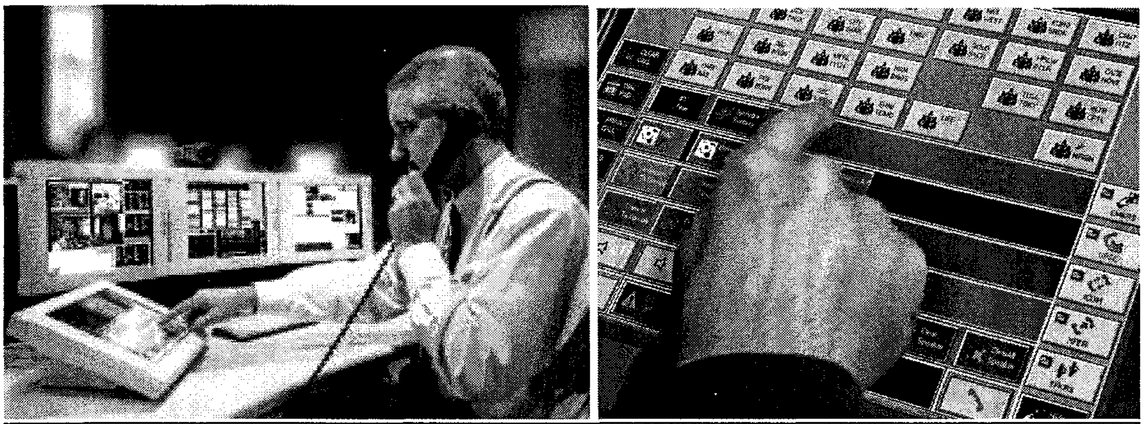

Figure 36: Concept 2010 Dealing Desk Showing Three Linked Display Screens and Touch Screen.

[306] Case Study Analysis – Concept 2010 Q4 'Relation to other contemporary work', Appendix 3, p.84.
[307] Heatley, D. et al. Concept 2010: BT's New Generation Dealing Desk. *BT Technology Journal,* 14 (4), Oct 1997, p.196.

For the purpose of this case study the focus was specifically on the data visualisation elements of the desk. These visualisations were developed in Superscape VR to illustrate the stocks, bonds or currencies in three dimensions. Additionally, the study covers BT's 'Navigate' VR demo, which highlights the ways traders might move through the data world and interact with the systems. The visualisation was based on data fed through an OTS, Open Trading System, which streams live market data to the trading room as shown below (see Figure 37). Traders interpret this numerical data as changing share price based on three colour codes, red (down) blue (no change) and green (up).

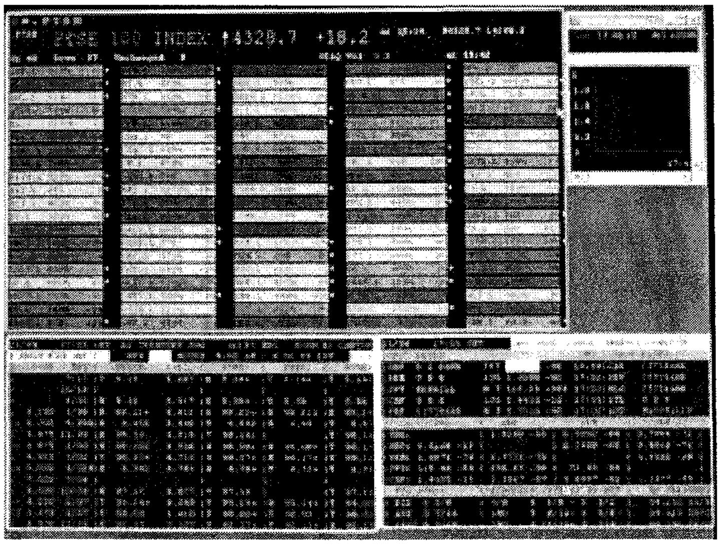

Figure 37: Screenshot of Numeric OTS Feed Data.

With the traditional 2D desktop system the information was contained in multiple individual windows, one for video, telephony, data etc with one activated at a time. In contrast, the virtual world was able to contain all these elements as objects in a single place, where they could be spatially arranged. For example, if a number of phone calls needed to occur at once, the avatars representing the callers could be placed geographically in the world, and consequently the sound would re-arrange accordingly (see Figure 38).

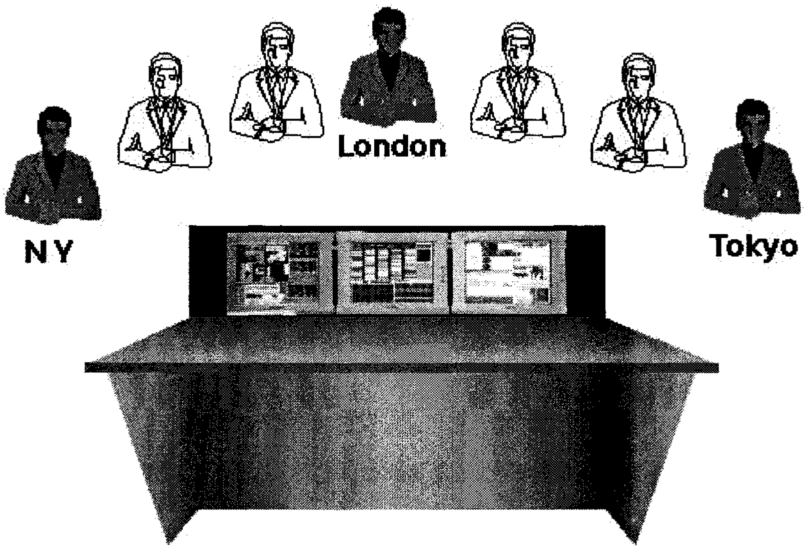

Figure 38: 3D Audio to Show Position of Virtual Avatars.

6.3.1 Description of the Nature and Aims and Objectives of the Original Project

The concept 2010 project was established to maintain market share by providing customers with a vision of where the technologies were going.[308] It has been demonstrated internationally at BTs dealing rooms, was first publicly shown at BT's 'Innovation '97' exhibition and has featured in a number of television programs including Equinox and Channel 4.[309] The aim of the work was to explore the possibility of 3D data visualisation.[310] It was motivated by the need to compete in the data market on added value rather than price, hence adding services to the same information.[311]

6.3.2 How it was Undertaken

The project comprised three visualisation challenges, namely data visualisation, information visualisation (taking the data and making something out of it) and navigation. In the 3D information visualisation, stocks are represented by coloured, vertical columns which moved dynamically according to the data received through the OTS system. The

[308] Case Study Analysis – Concept 2010 Q8-10 'Project Aims and Objectives', Appendix 3, p.85.
[309] Case Study Analysis – Concept 2010 Q16 'Data Sources', Appendix 3, p.92.
[310] Case Study Analysis – Concept 2010 Q7 'Justification', Appendix 3, p.83.
[311] Case Study Analysis – Concept 2010 Q7c 'Justification', Appendix 3, p.85.

shape of the column would show whether the stocks were rising or falling. This was achieved by using a cone shape, to illustrate increase or decrease by the volume of the cone. Should the share move outside the limits specified by the trader, it would animate with a wobble and shake to draw attention to itself. As the shares changed they moved forward step by step, revealing the history of the market if the world was viewed from the side. Over time, this created the impression of a field of corn, with waves of data like winds across the surface.

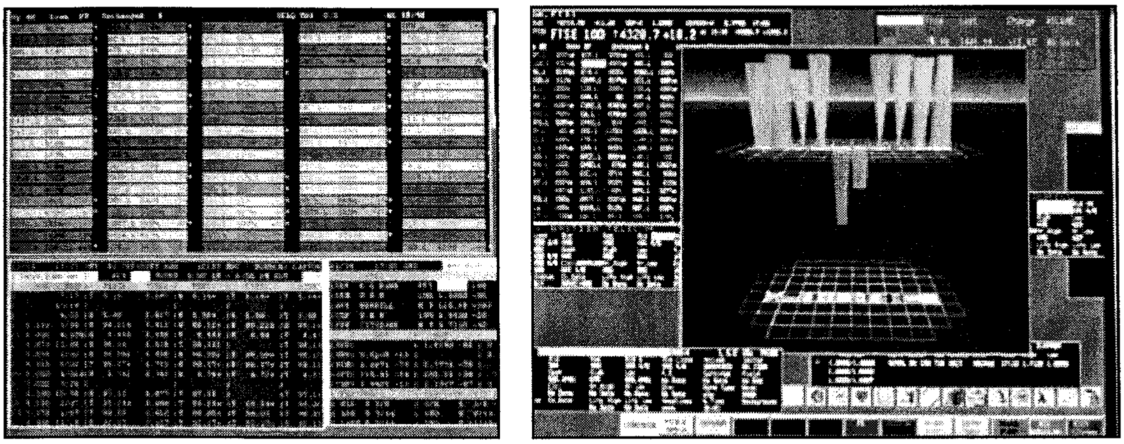

Figure 39: Screenshot of Traditional OTS Feed Data (left) and Concept 2010 3D (right).

6.3.3 Key Findings from the Concept 2010 Case Study

The case study material was analysed for critical issues, placed in Table 13. The semi-structured interview found that the key advantages of using 3D were considered to be the ability to spatially arrange data in contrast to flat overlapping 2D windows, and that it was felt to be a fun, intuitive and easy-to-use interface. The main technical disadvantage was in the software's ability to render surfaces, however it was noted that this problem had been solved with later versions. Additionally, it was considered difficult to represent concepts with no real-world counterpart such as the 'jump cube', which took users from one world to another like a hyperlink. Finally, it was noted that although sound was very important, it could be a disturbance if the computer was situated in an office environment, thus raising the issue of the impact of venue and context on VR. Additionally, documentation and project plans reveal a key attribute of the visualisation of data to be the specialist techniques for visual summary of complex information and relationships.[312]

In design terms, the aesthetic of the world was derived from William Gibson's description of cyberspace in *Neuromancer*.[313] A model was used from Superscape and adapted to present the new information. It was noted that real-world metaphors featured heavily in the financial traders' vocabulary, in that they described features of a good deal in geographic terms. The visualisation employed similar metaphors in considering the data to be like a field of corn with waves of data. However, data navigation was felt to be more of an issue than data visualisation, with this demonstration particularly focusing on navigational issues. Key issues here included the relativity of objects in VR where the scale and speed of things in the world were found to be connected. For example, with scale Fisher notes:

> "You get some really weird things when we were doing data driven graphing where a share price would climb, you know, two hundred percent and all the others would start dwarfing and you lost meaning then...we thought all of the others had shrunk, not that one of them had got bigger."[314]

Likewise, the 'flying carpet' was quite good at scaling people, as it provided a real-world scale to objects, relatively speaking. It was also noted that occasionally speed translates to size i.e. if you approached something slowly it appeared larger. Fixed landmarks were seen as essential tools for navigation with other representations being more transient, indicating their relative importance, such as crowds around an object.

In addition to the main interface, they experimented with an interface entitled 'grubby world' which was to show that when things get used a lot they get grubby, including the concept of 'burnt out icons.'[315]

312 Concept 2010 Project folder. Document I:\GlassDesk\TechnologyListV2.doc\13-Jun-96 p.1
313 Gibson, W. *Neuromancer.* Voyager, 1995.
314 Case Study Analysis – Concept 2010 Q52a 'Describe the animated aspects within the interface – did they have changed scale?' , Appendix 3, p.127.
315 Case Study Analysis – Concept 2010 Q50 'Did the interface demonstrate structure between entities or relationships between information?' Appendix 3, p.118.

Issue Classification		Results for Concept 2010
Representational Issues	**Metaphor (genre)** -realism/abstraction -dimensionality	• The aesthetic was "abstract with a bit of reality dropped in just to give it a bit of edge." • The aesthetics were derived from Neuromancer and a model created by Superscape. • One metaphor was that of a field of corn with waves of data moving 'like winds across the surface.' • Gravity was built in, yet you could fly through objects. • Concepts of wear: 'grubby world' which was to show that when things get used a lot they get grubby, including the concept of 'burnt out icons.' • Should the financial share move outside the limits specified by the trader, it would animate 'emotionally' with a wobble and shake, to draw attention to itself.
	-visual content **-audio content** **-haptics** **-olfactory** **-time/ animation**	• Data changes were achieved by using a cone shape, to illustrate increase or decrease by the volume of the cone. • 3D sound: callers could be placed geographically in the world and the sound would arrange accordingly. • Sound attached to objects. • Speed of animation i.e. wobble could indicate emotion • Sound could replace animation as a feedback loop.
Interaction Issues	**Narrative** -travel or way finding -action/education/ experience	• Nothing is pre-programmed, the user can go anywhere with a few fixed paths such as the 'magic carpet'. • Magic carpet was used to take inexperienced users through the space to orientate them. • Objects will react in pre-programmed ways when activated. • Attached to live data the VE would be autonomous.
	Navigation -mental model -spatial issues -scale	• Use of space to denote importance i.e. closer = important. • Click on and fly to (patented by Dave Linton). • 'Jump cube' makes hyperlinks to other worlds. • Relativity of scale: The scale and speed of things in the world were found to be connected in that objects behaviours impacted on the perception of other elements. • Speed translates to size i.e. if you approach something slowly it appears larger. • Fixed geography for landmarks. Then add moving, real-time data around them e.g. crowds. • YAW was turned off. • The concept of object orientated programming in a virtual world, generating macros using virtual pebbles to indicate a sequence of actions which can be flown through or dropped through gravity.
	Presence -immersion -kinaesthetic	• Although the project is desktop VR, a greater sense of immersion was possible due to the three flat screens arranged around the user. • The audio was felt to give as much as the visual in 'wrapping around you'. • It was tested with a helmet but it didn't add anything.

Table 13: Summary of the Results from the Concept 2010 Case Study.

Usability	**Conventions**	• The main convention was the reliance of Neuromancer as a narrative, which most people in VR understood well.
	Users -engagement -user-centred design	• It was felt that you could mix metaphors quite well in a virtual world without confusing users. • The whole thing was mental models based on the premise 'things that are easy to use get used'.
Design Issues	**Other Design issues** -guidelines	• Data navigation was felt to be more of an issue than data visualisation. • The design tried to be minimalist by focusing on the attributes of objects rather than their artefacts, e.g. a lift without doors. Like reverse engineering graphics to minimise rendering requirements. • 2D should always remain 2D, you don't perspectivise it or you get real problems. • Landmarks were very important.
	The medium -technologies -pros / cons	*Pros:* • Spatial arrangement of data in contrast to overlapping windows. • It was fun, easy-to-use and intuitive. • Visual summary of complex information and relationships. *Cons:* • Difficulty in representing textures due to the software. • Difficulty in representing ideas with no concrete reality e.g. 'jump cube'. • Sound can be intrusive in an office environment.
Technical	**Software** **Hardware**	• Modelled in Superscape version 3.5 to 4. • The software was felt to both constrain creativity and give them things they didn't know i.e. textures were limiting but gravity was a bonus. • The interface was using a space mouse.
Data	**Journals** **Film** **Project files**	• Heatley, D. et al. Concept 2010: BT's New Generation Dealing Desk. *BT Technology Journal,* 14 (4), Oct 1997. • Project File. • BT's 'Innovation 97' exhibition and *Competitive Edge* magazine. • Equinox and Channel 4 television. • VRML model by Syntegra.

Table 13: Summary of the Results from the Concept 2010 Case Study (Continued).

6.4 '3D Retail' Case Study

The 3D Retail project consisted of a visualisation of a user's living room, into which the person could put furnishings, wall coverings, carpets and curtains. The concept behind the work was to enable users to build their own rooms and decorate them virtually, review, specify and then purchase the materials over the internet, thereby eliminating the need for a visit to a shop.

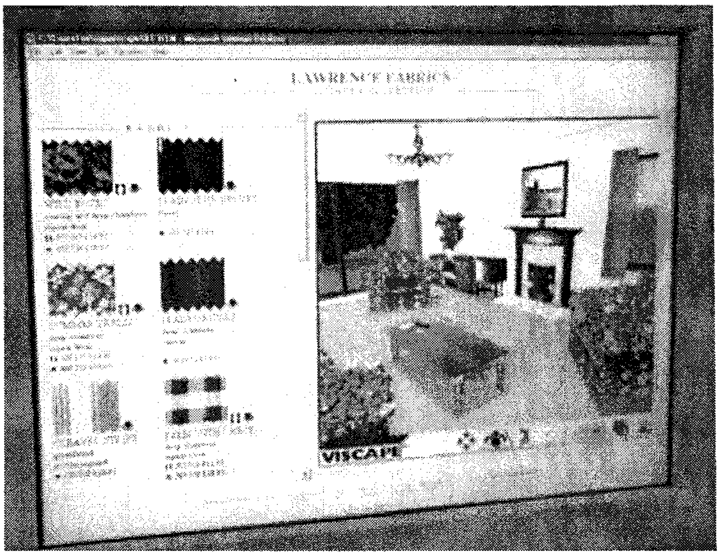

Figure 40: Screenshots of 3D Retail Showing 2D and 3D Interface.

This computer-based solution presented a number of advantages over physical shopping in that the user could:

- See what patterns and fabrics would look like when scaled onto furnishings or walls
- Specify exact measurements or quantities of materials for their requirements
- Establish a design theme for a room
- Shop around different outlets within one visualisation
- Eliminate the middle man costs.

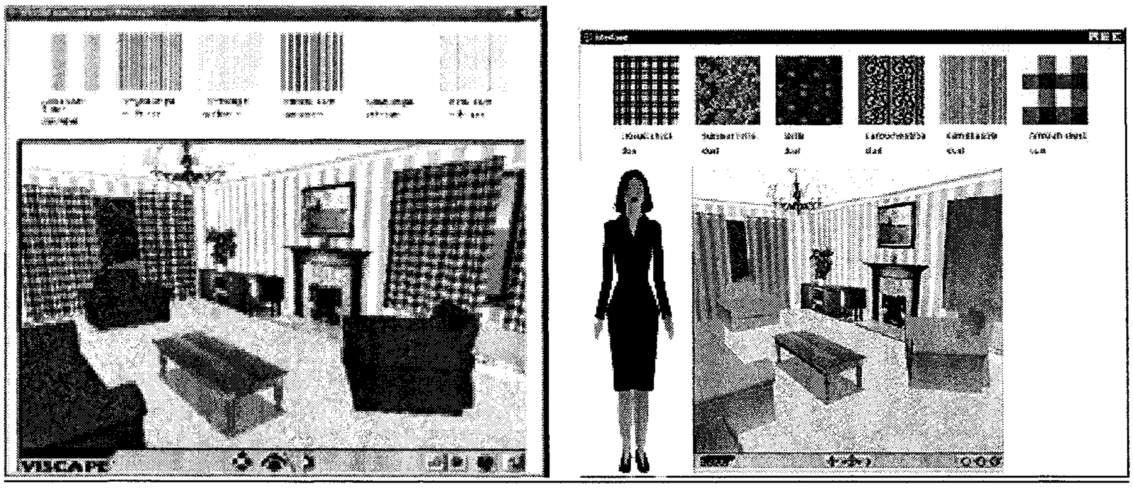

Figure 41: Two Screenshots of 3D Retail Showing Swabs and Curtains in Different Patterns.

6.4.1 Description of the Nature and Aims and Objectives of the Original Project

The 3D Retail concept originated from BT PropNet[316] an internet-based estate agency development project. It was noted that the rooms featured in Propnet had an absence of furniture and other objects and that this was missing from the offering. As Fisher notes: "It became clear that the houses we built were empty and they looked horrible."[317] The original objective was to develop new services that drive traffic to a particular website, and BT felt that 3D content attracted people.[318] As Fisher notes: "The thing was to create a new service which would drive up demand for all the other things BT can do - host websites, mine websites, charge for internet access."[319] In addition, it was felt that the content was fun and useful, providing services that people wanted to use. From the companies' perspective, the project would allow companies like IKEA and Laura Ashley to access, through data mining, unique data about their customers buying habits and personal preferences.

[316] Wittgreffe, J., Hobbs, G., Berresford, S., Fisher, K., & McRae, S., BT PropNet: A Commercial Property Trading Service for the Internet, *BT Technology Journal* 15 (2), April 1997, p.132-137.
[317] Case Study Analysis – 3D Retail Q1&2 'General Description', Appendix 3, p.145.
[318] Case Study Analysis – 3D Retail Q8-10 'Project Aims and Objectives', Appendix 3, p.148.
[319] Case Study Analysis – 3D Retail Q8-10 'Project Aims and Objectives', Appendix 3, p.148.

6.4.2 How it was Undertaken

BT collaborated with Computer Based Learning (CBL) and Superscape,[320] on the technologies and partnered with B&Q, Laura Ashley and Allied Carpets on the content. The concept was to develop a virtual room and then load textures (paint finishes, carpets, patterns and colours) dynamically into the space. To create a system that substituted one texture for another required significant coding and resulted in a patent for BT.[321] At the point of the interview the project was about to go to the public as a closed user-group trial for two retailers and selected customers.

6.4.3 Key Findings from the 3D Retail Case Study

The case study material was analysed for critical issues, placed in Table 14. The semi-structured interview found that the key advantages of using 3D were considered to be fun, ease of use and invisibility of the interface and technology, as was the ability to juxtapose things in the space and utilise different viewpoints to perceive the environment. It was also felt to allow users to see the impact of scale on objects and make design decisions, like a what you see is what you get (WYSIWYG) interface. In contrast the 2D was felt to offer better speed and familiarity to users.

In design terms, the interface was very iconic, with objects behaving similarly to their real-world counterparts. This aesthetic was used throughout the interface. Although this might imply an aesthetic design without much novelty or surprise, the interface did break conventions of shopping and retail, as Fisher notes:

> "The challenge which dawns on people is that most virtual reality shopping up until now, has been people wandering around virtual shops. It's not, what we're doing here is bringing the shop contents to the user and letting them add them all together in their own room or in a chosen room. And that's a very different shopping paradigm than has ever been put up, I think."[322]

In this sense the design approach was to develop a user-led solution to the problem of shopping rather than create novel visuals. This paradigm shift in solution is common in

[320] Case Study Analysis – 3D Retail Q14-15 'People involved', Appendix 3, p.153.
[321] Case Study Analysis – 3D Retail Q16 'Information', Appendix 3, p.159.
[322] Case Study Analysis – 3D Retail Q36 'How would you characterise the different interfaces?' Appendix 3, p.170.

design practice, yet as Fisher continues: "It is so fundamentally different that people don't even see the difference. It's so intuitive."[323] Additionally, it was noted that although Laura Ashley Fabrics was collaborating on the project, the representation of the room did not fit with its traditional brand because it contained modern technology and fittings and therefore the name Laurence Fabrics was used. In this sense the 3D VR brand and the real-world brand had referential incompatibilities.

Technological determinism was felt both to aid the design, with new features such as fogging, levels of detail and additional sonic capabilities, and constrain it with its limited colour palette. Clearly the interface was intended to reproduce the real fabrics and patterns therefore this colour limitation would affect the way the user perceived a material quality.

[323] Case Study Analysis – 3D Retail Q36 'How would you characterise the different interfaces?' Appendix 3, p.171.

Issue Classification		Results for 3D Retail
Representational Issues	**Metaphor (genre)** -realism/abstraction -dimensionality - object permanence	• The interface was very iconic with real-world objects such as sofas, tables and a fireplace in a virtual living room. • The objects were imported with their characteristics. 'Objects inside the world were alive'.
	-visual content -audio content -haptics -olfactory -time/ Animation	• The visualisation was called 'Laurence Fabrics' as it did not fit consistently with the brand of Laura Ashley, e.g. Laura Ashley doesn't have modern technology such as radiators and televisions in their show spaces but the visualisation did. • An interface was also built that was voice driven with speech generation and recognition technologies and tested by the BT speech group (The MUeSLI: MUltimodal Spoken Language Interfaces). • Objects are animated in real-world ways - curtains close, clocks tick and the fire glows and sounds accordingly. • Time was represented as real time (the clock had the correct time on it).
Interaction Issues	**Narrative** -travel or way finding -action/education/ experience	• The user starts with a white room and, bit by bit, is able to pick colours and textures to decorate the space. • If users put in their own room measurements the interface could quantify their needs, curtain lengths, paint volume etc.
	Navigation -mental model -spatial issues -scale	• The three dimensionality doesn't become obvious until you move. • There are stages of interactivity with the user being able to fly in space and interact with objects, like open cupboard doors. • It was felt to be easier to select in 2D and then apply to 3D, with other BT work indicating this by Mary Jones.
	Presence -immersion -kinaesthetic	• Desktop fish-tank VR due to the framing in 2D and the intended service delivery over the internet.
Usability	**Conventions**	• It was intended to be intuitive to a user and not challenge any conventions.
	Users -engagement -user-centred design	• The technology was intended to be invisible. • The interface was seen to be a 'what if' tool for users, where users could create different visual options. • Users have more control than they do in real-world shopping.

Table 14: Summary of the Results from the 3D Retail Case Study.

Design Issues	**Other Design issues** -guidelines	• The solution was felt to be a different paradigm from the obvious choice of representing a shopping experience.
	The VR medium -technologies -pros / cons	*Pros:* • Fun, easy to use. • Invisibility of what was going on. • The juxtaposition of things. • You can change your view of the curtains or sofa and act realistically in the space i.e. sit on the sofa and view the space. • Viewpoint is as infinite as interactivity. • Appreciation of scaling. People could judge the effect of a pattern on a surface, which they had found difficult using samples. • Interactive and intuitive. *Cons* • 2D was better for speed and familiarity to users.
Technical Issues	**Software** **Hardware**	• Innovation of having textures loading live into the window and replacing previous surfaces, therefore keeping file size small. • Modelled in Superscape's VRT version 5. • The software was felt both to constrain (colour palette) and aid the design (added features like fogging, levels of detail, advanced texturing ability and sound capabilities). • The software encouraged an 'economical' design. • Webmaster software was noted as having a large library of pre-built objects. • Superscape was suggested to be designer-friendly in comparison to C++. • The interface was using a space mouse.
Data	**Journals/Film/ Project files**	• Project File. • Innovation 97 website. • *Competitive Edge* magazine article. • Three discrete visualisations. • LWT interview 'Countdown to the Millennium' 20/10/96.

Table 14: Summary of the Results from the 3D Retail Case Study (Continued).

6.5 Other Case Studies Investigated

Forum - A VRML graphical front for audio conferencing i.e. sharing documents (development based, using technology for usability). This project was not featured in the interviews.

6.6 Cross-case Analysis of the Secondary Case Studies

The case studies from the second stage were analysed through pattern matching to highlight aspects of commonality across the cases (to be discussed in Chapter 7). From this the results were organised into three categories, namely: attributes of VR across cases; significant individual case study attributes; emerging issues and recommendations for design.

6.6.1 Attributes of VR Across Cases

From the results of the secondary case studies, the following key attributes of VR were identified in more than one case study:

- Intuitive and 'self selling': The ability of VR to communicate to different users in a consistent manner; one model gets an amazingly consistent response
- Interactive
- User control: ability to set viewpoint, user control, a 'what-if' tool and ability to adjust the viewpoint
- Spatial arrangement of data: juxtaposition of things and the use of space to communicate meaning i.e. geography, scale
- Fun
- Easy to use
- 3D sound.

6.6.2 Significant Individual Case Study Attributes

In individual case studies, attributes were identified including:

- Scale: Relativity of scale, speed translates to size and objects grow relatively. Appreciation of scale using the medium (e.g. providing a child's viewpoint in 3D Retail).

- Visual summary of complex information and relationships (also noted in Reuters)[324]
- Multimodal displacement: opportunities where sound can replace vision[325]
- Real time: Ability to visualise data that changes real time (Concept 2010).

6.6.3 Emerging Issues and Recommendations for Design

- Effect of software on design
- Role of mental models
- Role of navigation including landmarks
- Limitations of realism
- The need for 'object permanence'
- Role of virtual brands
- Suitability of VR software as a design tool: including speed at which designers could generate animation and the control of the visualisation rather than be reliant on the programmer.

The phase two case study results were collated into Tables 15-21 to enable pattern matching to take place, allowing aspects of commonality and difference to emerge. The results contributed to the second phase communication models and will then be discussed and interpreted further in Chapter 7.

[324] Garrison, G. et al. The Usability Group at Reuters: Virtually Global. Organisation Overviews. *CHI96 Conference Proceedings,* 1996, p.137.
[325] Sherman calls this sensory substitution. Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.221.

Meta-Matrix Ordered by Cases: Illustrating Case Study Results	
Case study	**Representational issues**
Call Waiting	• Emotional iconography. • Real-world attributes were used, such as shrinking and 'dying away', gravity and resistance or 'slip'. • 'Slip' was used on objects (like the talking cube) to add realism. • Breaking real-world conventions, calls (cubes) would 'disappear' when finished. • Used real word and conventional audio. • They didn't 'build' anything for it, the objects were from clip objects. • Cartoon flashing arrows were used. • Sounds used were 3D clip sounds. • Sound was considered to be vital.
Concept 2010	• The aesthetic was 'abstract with a bit of reality'. • The aesthetics were derived from Neuromancer. • One metaphor was that of a field of corn with waves of data moving 'like winds across the surface'. • Gravity was built in, yet you could fly through objects. • Concepts of wear: 'grubby world' and 'burnt out icons'. • Icons wobble and shake 'emotionally' to draw attention to themselves. • Data changes increase or decrease the volume of the cone. • 3D sound: callers could be placed geographically in the world. • Sound attached to objects. • Speed of animation i.e. wobble could indicate emotion. • Sound could replace animation as a feedback loop.
3D Retail	• The interface was very iconic with real-world objects. • The objects were imported with their characteristics. • Real-world and virtual brand compatibility issues. • A voice driven interface was also built. • Objects animated in real-world ways - curtains close, clocks tick and the fire glows and make sounds accordingly. • Time was represented as real time (the clock had the correct time on it).

Table 15: Cross-case Analysis for Representational Issues.

Case Study	Interaction issues
Call Waiting	• A logical, sequential educational experience. • Things outside the field of view were inconsequential. • It was easier to build narrative from the iconic to the symbolic, than the symbolic to the iconic. • Putting a telephone keypad in the 3D frame made it difficult to use. • 'This is all about mental models'. • Minimal movement in the 3D world. • Users could change the viewpoint but had limited navigation. • 'Reset the world' feature was useful. • Screen-based, Fish-tank VR was easier to teach with than immersive VR.. • No kinaesthetic.
Concept 2010	• Nothing is pre-programmed, the user can go anywhere. • A few fixed paths such as the 'magic carpet'. • Magic carpet was used to take inexperienced users through the space. • Objects will react in pre-programmed ways when activated. • Attached to live data, the VE would be autonomous. • Use of space to denote importance i.e. closer = important. • Click on and fly to (patented by Dave Linton). • 'Jump cube' makes hyperlinks to other worlds. • Relativity of scale. • Speed translates to size. • Fixed geography for landmarks. Then add moving, real-time data around them, e.g. crowds. • YAW was turned off. • The concept of object-orientated programming in a virtual world. • Although the project is desktop VR, a greater sense of immersion was possible due to the three flat screens arranged around the user. • The audio was felt to give as much as the visual in 'wrapping around you'. • It was tested with a helmet but this didn't add anything.
3D Retail	• The user starts with a white room and bit by bit is able to pick colours and textures to decorate the space. • If users put in their own room measurements the interface could quantify their needs, curtain lengths, paint volume etc. • The three dimensionality doesn't become obvious until you move. • There are stages of interactivity with the user being able to fly in space and interact with objects, like open cupboard doors. • It was felt to be easier to select in 2D and then apply to 3D. • Desktop fish-tank VR was used due to the intended service delivery over the internet using a 2D frame.

Table 16: Cross-case Analysis for Interaction Issues.

Case Study	Usability
Call Waiting	• It was felt people would not need to understand computer conventions. • Technically 'distancing' was used to speed the rendering. • One model could be used to communicate to different users i.e. customer, sales people, service designer (all had a shared mental model). • "We have had an amazingly consistent reaction to it" by users.
Concept 2010	• The main convention was the reliance on Neuromancer as a narrative, which most people in VR understood well. • It was felt that you could mix metaphors quite well in a virtual world without confusing users. • The design was led by mental models, based on the premise 'things that are easy to use get used'.
3D Retail	• It was intended to be intuitive to a user and not challenge any conventions. • The technology was intended to be invisible. • The interface was seen to be a 'what if' tool for users, where users could create different visual options. • Users have more control than they do in real-world shopping.

Table 17: Cross-case Analysis for Usability Issues.

Case Study	General Design Issues and Guidelines
Call Waiting	• 'How on earth do you represent a call? Was the biggest thing'. • The team worked iteratively with a 'suck it and see' approach. • Emcons should be structured and consistently applied.
Concept 2010	• Data navigation was felt to be more of an issue than data visualisation. • The design tried to be minimalist by focusing on the attributes of objects rather than their artefacts. i.e. a lift without doors. Like reverse engineering graphics to minimise rendering requirements. • 2D should always remain 2D, you don't perspectivise it or you get real problems. • Landmarks were very important.
3D Retail	• The solution was felt to be a different paradigm from the obvious choice of representing a shopping experience.

Table 18: Cross-case Analysis for General Design Issues and Guidelines.

Case Study	Design Issue – the VR Medium Pros.
Call Waiting	• Once people saw the visualisation it became self-selling, it didn't need explaining. • Interactive. • Speed of production a particular benefit making it easier to create than using animation software. • More flexiblé to solve problems. • Control over viewpoint and the ability to change viewpoints. • Smaller file size than an equivalent animation. • The ability to animate a mental model. • It got used totally out of proportion to the time it took to create it. • Design control over the visualisation by the creator, rather than via a technician or programmer. • The ability to make many of changes easily, therefore highly creative [to develop iteratively].
Concept 2010	• Spatial arrangement of data in contrast to overlapping windows. • It was fun, easy to use and intuitive. • Visual summary of complex information and relationships.
3D Retail	• Fun, ease of use, invisibility of what was going on. • The juxtaposition of things. • Users can change their view of the curtains, sofa etc. and act realistically in the space i.e. sit on the sofa and view the space. • Viewpoint is as infinite as interactivity. • Appreciation of scaling. People could judge the effect of a pattern on a surface, which they had found difficult using samples. • Interactive and intuitive.

Table 19: Cross-case Analysis for the VR Medium – Pros.

Case Study	Design Issues - the VR Medium Cons.
Call Waiting	• Software tools poorly designed; inconsistent interface; UI difficult to use.
Concept 2010	• Difficulty in representing textures due to the software. • Difficulty in representing ideas with no concrete reality i.e. 'jump cube'. • Sound can be intrusive in an office environment.
3D Retail	• 2D was better for speed and familiarity to users.

Table 20: Cross-case Analysis for the VR Medium – Cons.

Case Study	Technical issues
Call Waiting	• Modelled in Superscape version 2.53. • The software was not felt to constrain the concepts. "It was the ideas not the tool that was the problem". • Software did affect the design – the modelling had to be very basic to allow the machine to do quicker frames. This means you end up with a cube rather than a sphere, for example. • The designers felt they didn't really fully utilise the 3D world in this project but rather used it as an animation tool. • Interface was using a space mouse.
Concept 2010	• Modelled in Superscape version 3.5 to 4. • The software was felt to both constrain creativity and give the designers things they didn't know i.e. textures were limiting but gravity was a bonus • The interface was using a space mouse.
3D Retail	• Modelled in Superscape's VRT version 5. • Innovation of having textures loading live into the window and replacing previous surfaces therefore keeping file size small. • The software was felt to both constrain (colour palette) and aid the design (added features like fogging, levels of detail, advanced texturing ability and sound capabilities). • The software encouraged an 'economical' design. • Webmaster software was noted as having a large library of pre-built objects. • Superscape was suggested to be designer-friendly in comparison to C++ • The interface was using a space mouse.

Table 21: Cross-case Analysis for Technical Issues.

6.7 Second Expert Forum – Issues in Practice

The second peer review event for the research was focused on issues in practice. This was a Design Research Society Colloquium, held at the Centre for Design Research in Newcastle and entitled 'Multi-viewpoint: Shaping the Human Computer Interface'. The conference aimed to look at furthering design practice by revealing insights into the way practicing designers used computers to design three dimensional interfaces in virtual reality, computer-aided design and 3D modelling. The aims of the event were to draw expert opinion on the subject and to present the findings of the case studies through the communication models. These were broken down as follows:

1. Obtain advanced knowledge in the field of HCI design issues
2. Receive peer review, feedback and validation of the work (criticism or endorsement of the content and process).

In terms of content, it was focused on creating a bridge between theory and practice in HCI Design by looking at best practice and considering where the future of HCI might lead.

6.7.1 Criteria for Selection of Key Speakers

The speakers represented experts in the field of virtual reality, computer-aided design and 3D Modelling. The panel was selected based on members perceived understanding of the practical issues inherent in their chosen medium. This was in direct contrast to the theoretical standpoint of the first forum, and was intended to provide insight into the issues from a designer's perspective. A list of speakers can be seen in Table 22.

Individual	Organisation	Expertise
Dave Roberts	IBM, Ease of Use	HCI Expert
Walter Penndorf	Aka Design Visualisation	VR Designer
Steve Bailey	Octo Design	Product Designer
Professor Harold Thimbleby	Middlesex University	HCI
Nina Warburton	Random Product Design	Product Designer
Tobias Misera	Centre for Design Research	Interface Designer
Kevin McCullagh	Freelance	Design Strategist
Kim Fisher	BT Laboratories	VR Designer

Table 22: DRS Expert Colloquium Participants.

6.7.2 Methodology for the Event

The conference was held at The Centre for Design Research, at the University of Northumbria. A room was organised within the centre with a capacity of 50 people. Video recording capabilities were set up to record the data for later analysis. The agenda initially was briefly to contextualise the day with presentations by the researcher and Harold Thimbleby, followed by expert practitioners describing their experiences in creating digital designs. Finally, the presentation by Kevin McCullagh was intended to draw together the theory and practice elements and discuss the implications of the relationship of theory to practice. The speakers were invited to prepare a 15 minute presentation on a topic chosen by the researcher. The tentative titles were created to provide the necessary focus to the event without being overly deterministic. The list of titles given was as follows:

"What is the Computer Medium?" Harold Thimbleby.
"Can Three Dimensionality Reveal New Knowledge?" Andrea Cooper.
"Using 3D, a Practitioner's Perspective - the Pitfalls and Potentials." Kim Fisher.
"Choosing the Real-world as your Metaphor." Dave Roberts.
"VR as a User Perspective." Walter Penndorf.
"How Real?" Steve Bailey.

"The Integration of the Digital in the Design Process." Nina Warburton.
"Industrial Designers, the New Craftsmen of Media?" Tobias Misera.
"How can Theory Assist Practice?" Kevin McCullagh.

6.7.3 Data Collection

A video recording of the event was taken, from which key issues have been transcribed (see Appendix 7). Additionally, speakers submitted their presentations for the researcher to review after the event. A website was created to disseminate the findings, and encourage discussion and debate, it is located at: http://vision.unn.ac.uk/ion/visualise. This site represented a forum to discuss the role of three dimensional digital form in HCI and VR, and charted key events as well as providing general sources of information about the research area. A map of this site can be seen in Figure 42.

6.7.4 Treatment of the Data

The practitioner insights contributed to an ongoing refinement of the research propositions and findings. In particular the event served to highlight any gaps in the research framework that might have resulted from the early stages being led by a more theoretical standpoint. The transcripts where typed and key issues highlighted, from the nine presentations, three were practitioners using VR. These papers have formed the summarised conclusions.

Three of the speakers specifically talked about the design issues of VR, Kim Fisher (KF), David Roberts (DR) and Walter Penndorf (WP). These presentations have been included in Table 23.

6.7.5 Combined Results for the DRS Expert Colloquium

Issue Classification		Results
Representational Issues	**Metaphor (genre)** -realism/abstraction -dimensionality	• Don't put in VR windows from OS as it kills the metaphor. (KF) • Show things that don't exist rather than modelling a tea cup. (KF) • More realism as it allows users to interact and influence space with different input and output. (WP)
	-visual content -audio content -haptics -olfactory -time/ Animation	• Appropriate detailing, visual human avatars, the abstract holds the illusion much better than the realist. (KF) • Message across eyes, ears, intuition, spatial relationship, audio. (KF) • Don't forget sound, it is even more powerful than the visual but can't be used easily in open plan offices. (KF) • Ideally, manipulate all of the users senses.(WP)
Interaction Issues	**Narrative** -travel or way finding -action/education/ experience	• Interactive 3D worlds, it is not a story you are telling; in media you can control the story by limiting paths. Don't put paths in VR. (KF) • Likewise you can have real clocks showing real time (KF) • Software agents going out there and finding data, and presenting it to you in a way that you understand – persona (KF)
	Navigation -mental model -spatial issues	• Beware of fly-through vertigo. (KF) • Peripheral vision. (KF) • Not representing data but getting around data – navigation (KF) • Navigation approaches. (DR)
	Presence -immersion -kinaesthetic	• Internet allows you to connect without someone getting in the way - shared spaces (KF)
Usability	**Conventions**	*Not covered*

Table 23: Selected Design Considerations from DRS Expert Colloquium.

	Users -engagement -user-centred design	• Don't use 3D just because you can, because it confuses people. (KF) • Builders may worry about VRT VRML standards but users don't. (KF) • Matching the visualisation to the viewer – a stock market trader has a different preference, he can see numbers, so make sure that you are trying to visualise the things that people want you to. (KF) • A metaphor too far, a PC, a window, a browser, then a shopping mall. Throw away the metaphor and think about users.(KF) • Make it fun. If it is really fun people will use it. (KF) • Tomorrow's customers have excellent hand-eye co-ordination which helps in using VR. (KF) • The issue of productivity has been addressed in all aspects of Real Spaces VR (DR)
Design Issues	**Other Design issues**	• No point in modelling a chair that you can't sit on. (KF) • You go shopping in a real mall in a similar way, virtual shopping should be treated as different. (KF) • Frame rate increase means you get more cells in between. (KF) • Change colours and surfaces and see them on the three dimensional model. (KF) • Likewise, you can check that doors will open and that furnishings will fit. (KF) • Design of the world. (DR) • Object interaction. (DR) • Identify new tools for the design process. (WP) • Parts of a prototype to simulate how they go together. (WP)
	The medium -technologies -pros / cons	• Live modelled world, you get the data to build it live in front of you. (KF) • Multiple views of the data. (KF) • Jump to other worlds. (KF) • Beyond the physical you can view it from a distance. (KF) • The objects can have affordances so that if you try and put a chair near a fire then it will jump up and change its behaviour. (KF) • Ability to perform design changes quicker and cheaper. (WP) • Ability to use for real time testing. (WP) • Ability to visualise difficult to access data. (WP) • For marketing and sales, the advantage is to be able to modify colour without having to have real physical cars in the showroom. (WP) • Documentation tool for different design stages. • Need simpler user interfaces. (WP)

Table 23: Selected Design Considerations from DRS Expert Colloquium (Continued).

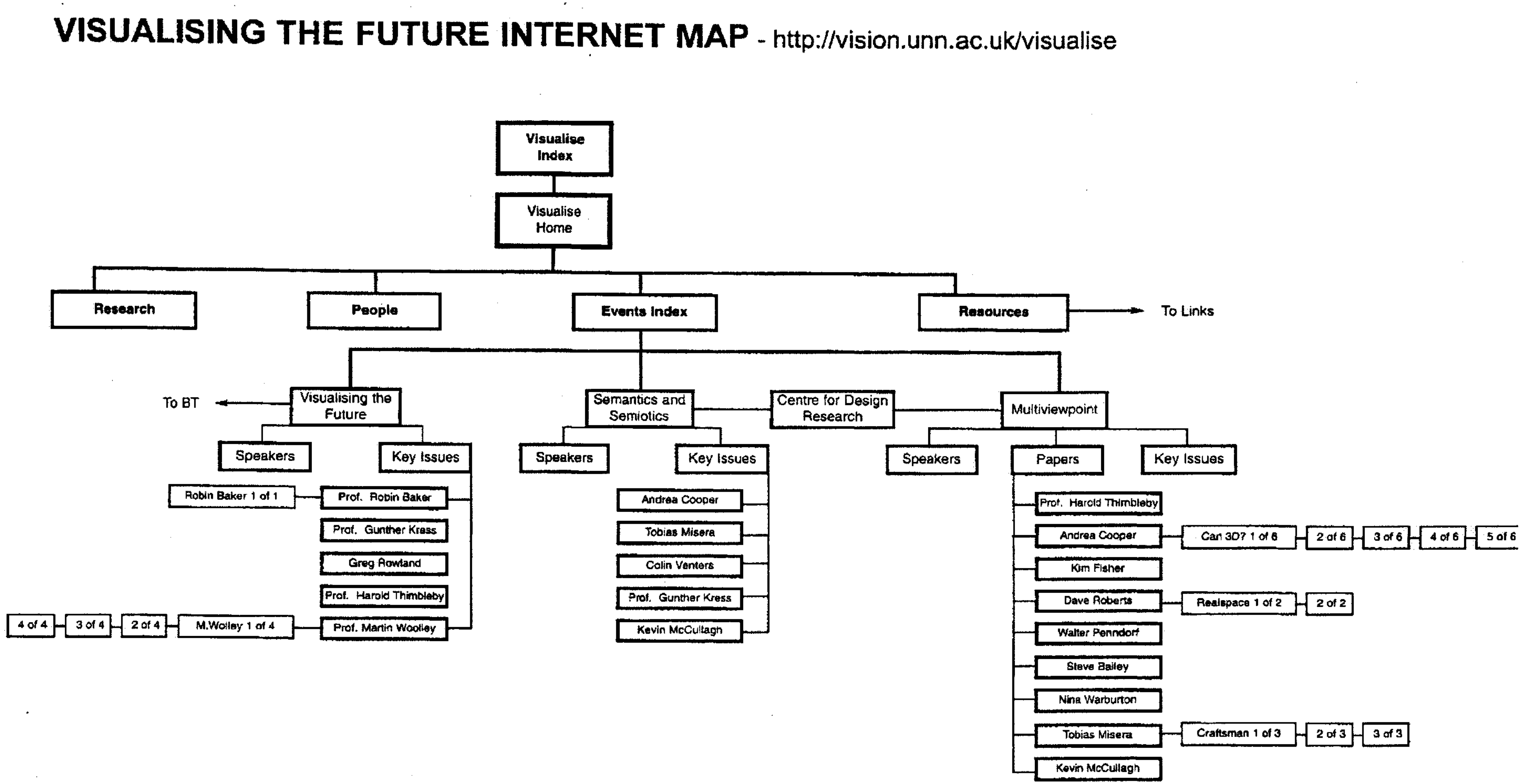

Figure 42: Overview of 'Visualise' Website. (23.11.98)

6.8 Secondary Communication Model Demonstrating Media Virtues

The conclusion to the secondary case study phase of the research programme was the refinement of the earlier communication models to demonstrate different representations' generic virtues and constraints as well as provide a mental model illustrating the field.

6.8.1 Interpretation of the Findings to the Model of Communication

The communication model shown in figure 43 was derived from a synthesis of all of the previous findings, in particular the literature review, interviews and expert forum. The model was developed to illustrate the research through a theory-building technique as discussed in 4.7 and illustrated in Figure 22. The process of theory building followed a divergent-convergent approach that allowed different criteria to be synthesised and subsequently analysed and evaluated. To create the model, communication theories were cross-related and examined to highlight correlation and provide an integrated visual model that expresses the concepts. The model was built iteratively with a number of sketch models being developed and trialled with case study content prior to the final model illustrated being defined. The criteria for selection of the components of the model were based on their perceived value and relevance to designers and design practice. The iconic, symbolic continuum was an important organising theory as deduced from the literature review and therefore formed a defining component of the final model. Similarly, the classification of media in the literature review according to dimensionality was felt to be an important organising principle and allowed for the contextualisation of VR in relation to 2D and other media. This was an important component to allow for comparison between different media examples in the model.

6.8.2 Description of the Key Features of the Model

This model has been achieved by mapping the characteristics of different modes of representation, in terms of communication theory, in order to create a context for examining digital interface. The model aims to highlight both the commonality and differences that exist across different modes of representation and therefore applies a structure to the relationship between the more widely used mimetic interface and the abstract symbolic interface. It is suggested that the model of communication highlights many of the issues involved in communication studies in a manner that can be accessible to the designer, demonstrating the interrelation of the factors involved. It may also provide a descriptive framework within which the unique virtues of three-dimensional images might be considered. This should enhance the designer's understanding of the medium so they can design more appropriately for a given context.

6.8.3 Communication Model Demonstrating Media Virtues

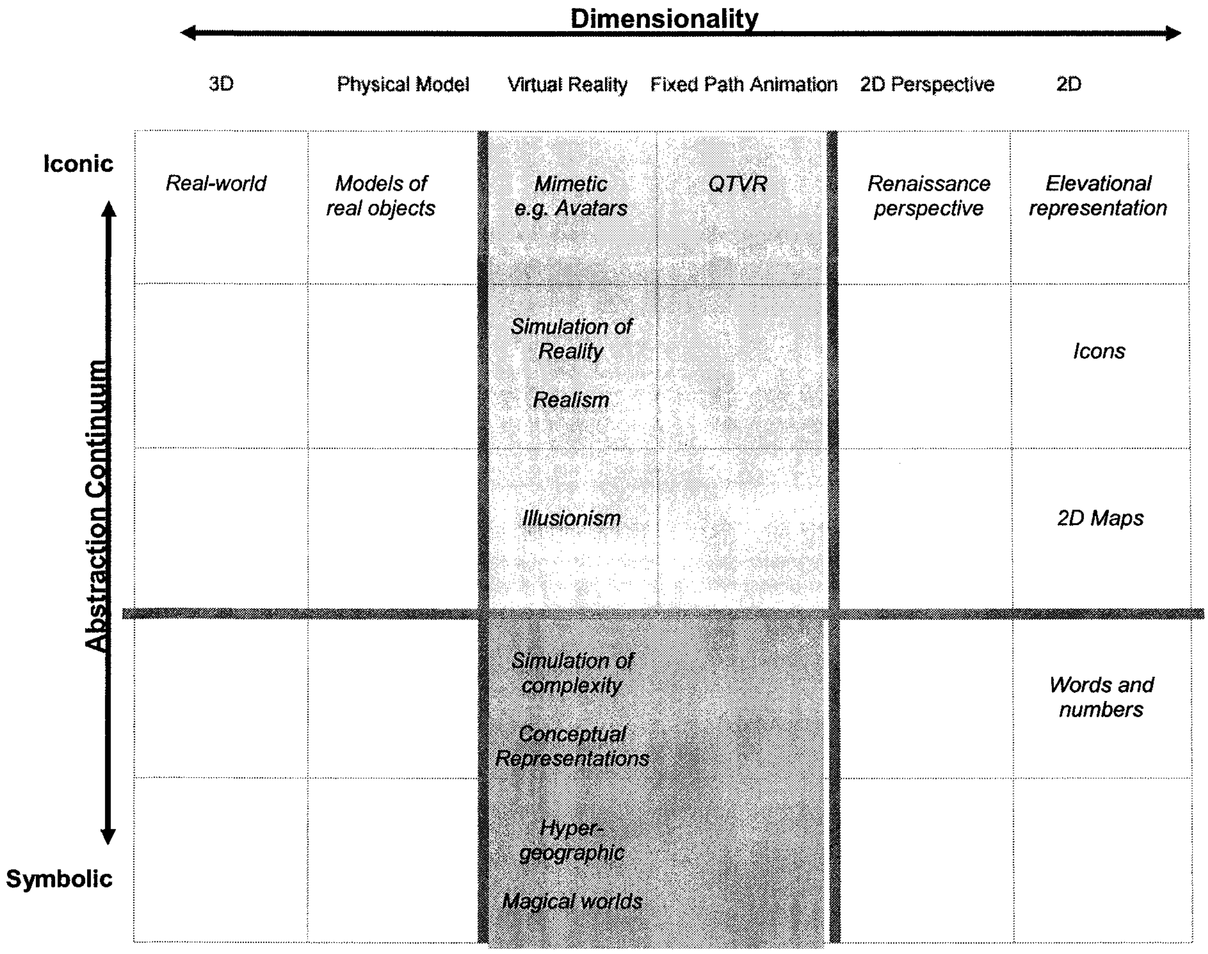

Figure 43: Taxonomic Model Identifying Key Characteristics of Media Virtues Populated with Indicative Content (in italics).

This has resulted in a matrix that maps across the top dimensionality (i.e. 2D, 2D perspective, fixed path animated 3D, VR, 3D), against the following key considerations; modes of representation (i.e. symbol, index, icon). The shaded sections show the areas of case studies in this research. The value of this taxonomy has been to make explicit the nature of the differences *within* the digital three-dimensional interface, as well as positioning it contextually in relation to other modes of representation. The phase one and phase two case studies were integrated into the communication model as examples of practice in Figure 44.

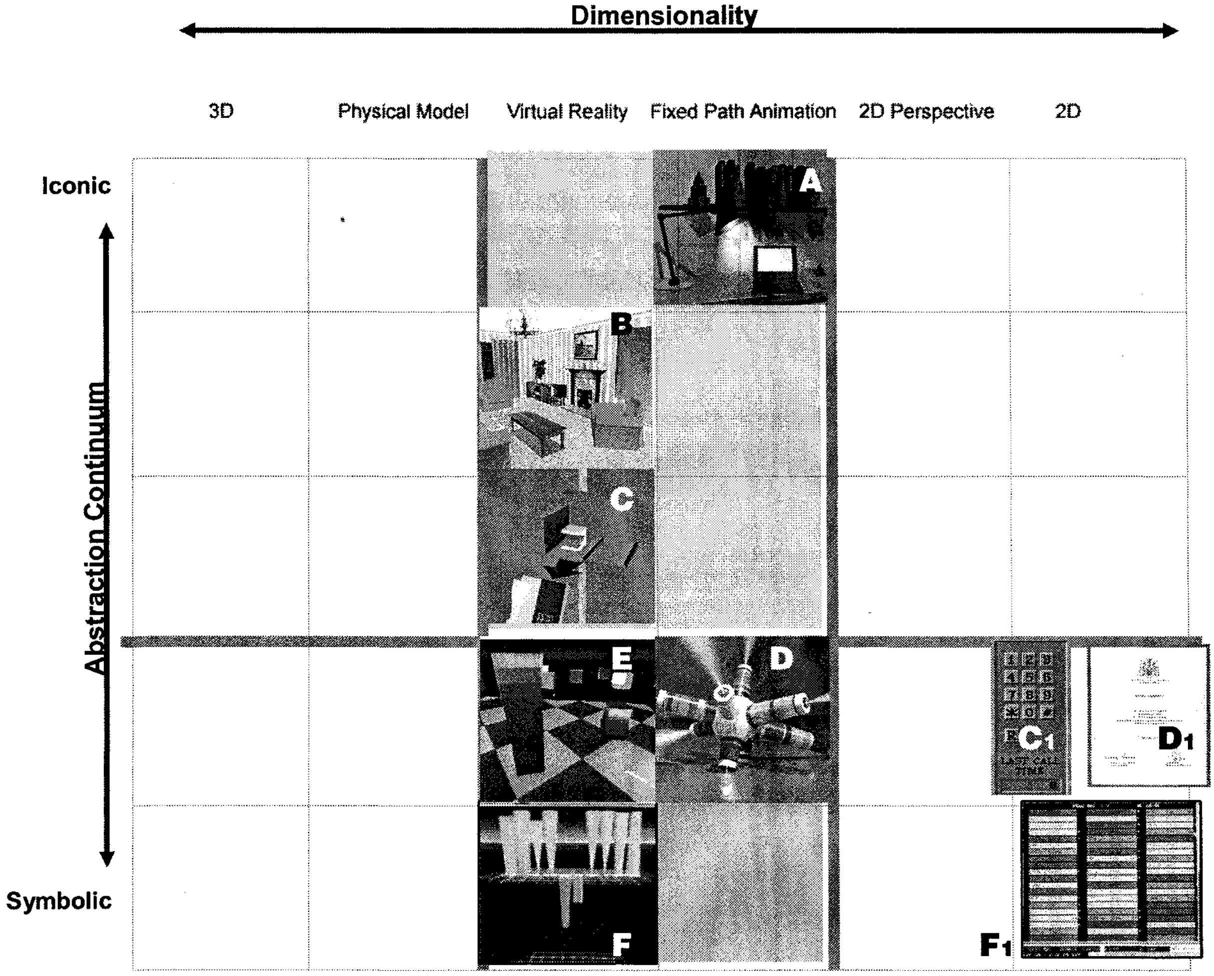

Figure 44: Taxonomic Model Populated with Research Case Studies.

The research case studies have been placed within the model to both test and illustrate the framework with examples of practice. It is clear from this which case studies are virtual reality and which are multimedia or fixed path animation based on their position in the horizontal axis. Likewise, the cases have been positioned on the vertical axis showing the symbolic-iconic continuum discussed in the literature review. The case's position was determined by whether the interface signs were realistic or conventional. In detail the positioning is as follows which have been lettered accordingly:

- A - Knowledge = Power was a virtual learning environment based on a real world classroom metaphor, it utilised high-end Alias Wavefront images and was highly iconic therefore is positioned at the top of the model.

- B - The 3D retail project represented real objects in a virtual world which were intended to have a direct likeness to the user's living room making it a mimetic interface.
- C - Call Waiting utilised basic geometric shapes and cartoon representations which had human-like characteristics. To understand the interface the user needed some conventional knowledge. In comparison, C_1 shows the same call waiting service as undertaken by keying numbers using a telephone keyboard and needed more conventional knowledge and therefore is shown further down situated in the 2D column.
- D - Sculptural Metamorphosis was a three dimensional representation of a person's educational achievement, it employed metaphors from the real world yet was highly conventional and had no real world direct counterpart. In comparison, D_1 shows a typical exam certificate which is conventional yet is well understood culturally to represent educational skills and experience using text grades A, B, C etc.
- E - Emotional Icons used an abstract set of icons with characteristics of emotion to communicate meaning, they were visually symbolic.
- F - Concept 2010 dealing room visualisation illustrated the stock market using abstract representations to represent immaterial stock values. Volume and scale showed rising and falling values. F_1 shows the same shares illustrated with numeric stock market OTS data which is highly conventional.

This communication model is intended to serve as a 'mental model' for designers to draw from, to make explicit some of the underpinning communication theories.

6.8.4 Methodology for Testing and Validation of the Model

The model was presented at an event at the Centre for Design Research, with a view to getting feedback on its communication value from designers. A group of designers from the different design disciplines attended the session and discussed the implications of the model on the way designers work. Figure 45 shows the model used with a range of representations across all of the dimensions.

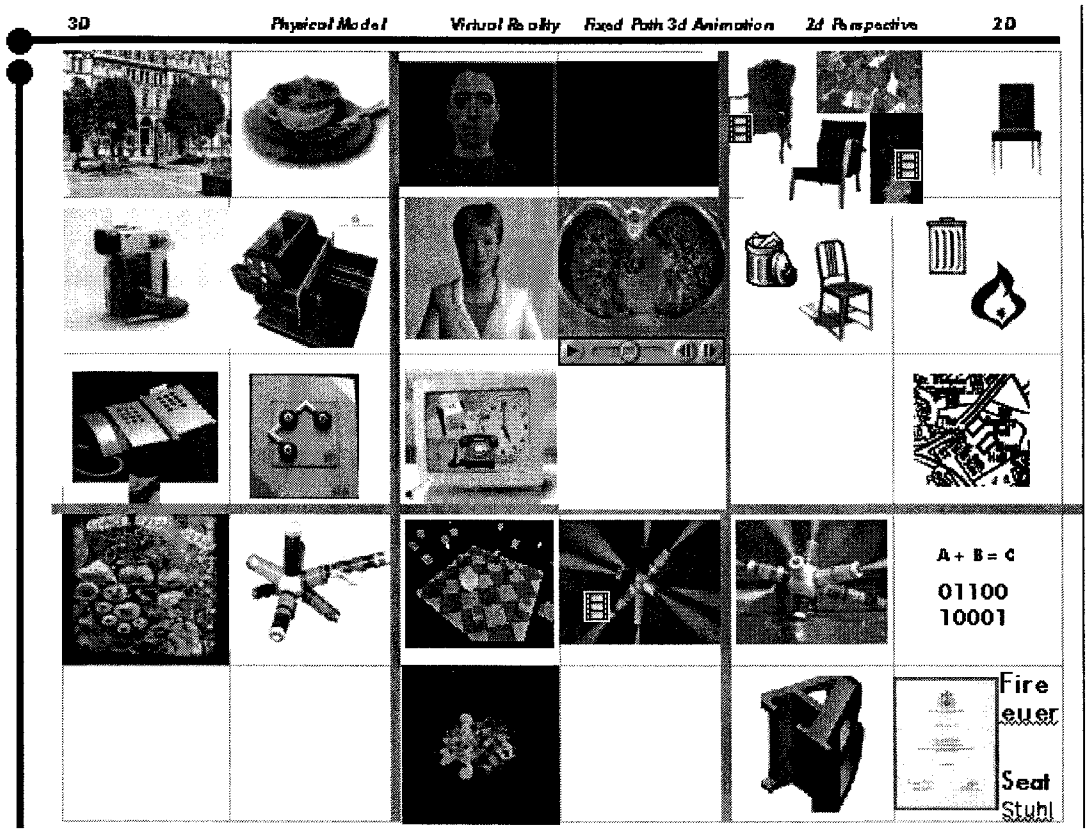

Figure 45: Taxonomic Model Populated by Case Studies and Other Examples.

It was considered that the model could enable designers to incorporate the theories of communication studies more readily in their practice. During this session the gaps were felt to be as interesting as the content in the matrix, because they highlight areas for future practice. Key findings from the session were that it was a good mapping tool and that it could be extended in a number of ways (as indicated in the recommendations Section 9.1.6). Examples cited included the possibility to overlay time, representing the emergence of different media in the model e.g. from the Renaissance to present day. In addition, technique or genre could be represented, to illustrate the effects of different media for example photography, computer, pencil, and paint. The discussion also covered psychological preference building on research by Bruner into personality and learning modes. Bruner considered learning to be based around the development of three skills; enactive skills (manipulating objects, spatial and physical awareness), iconic skills (visual recognition and the ability to compare through likeness) and symbolic skills (abstract reasoning). As an outcome of the review the model was developed further to add a diagonal showing modes of engagement according to Bruner as provisionally shown in figure 46. In this illustration the enactive skills are positioned relative to the physical world 3D dimensionality, whereas the symbolic skills are placed relative to the symbolic end of the abstraction continuum. This additional element is tentative, however it showed promise during the designers' discussion.

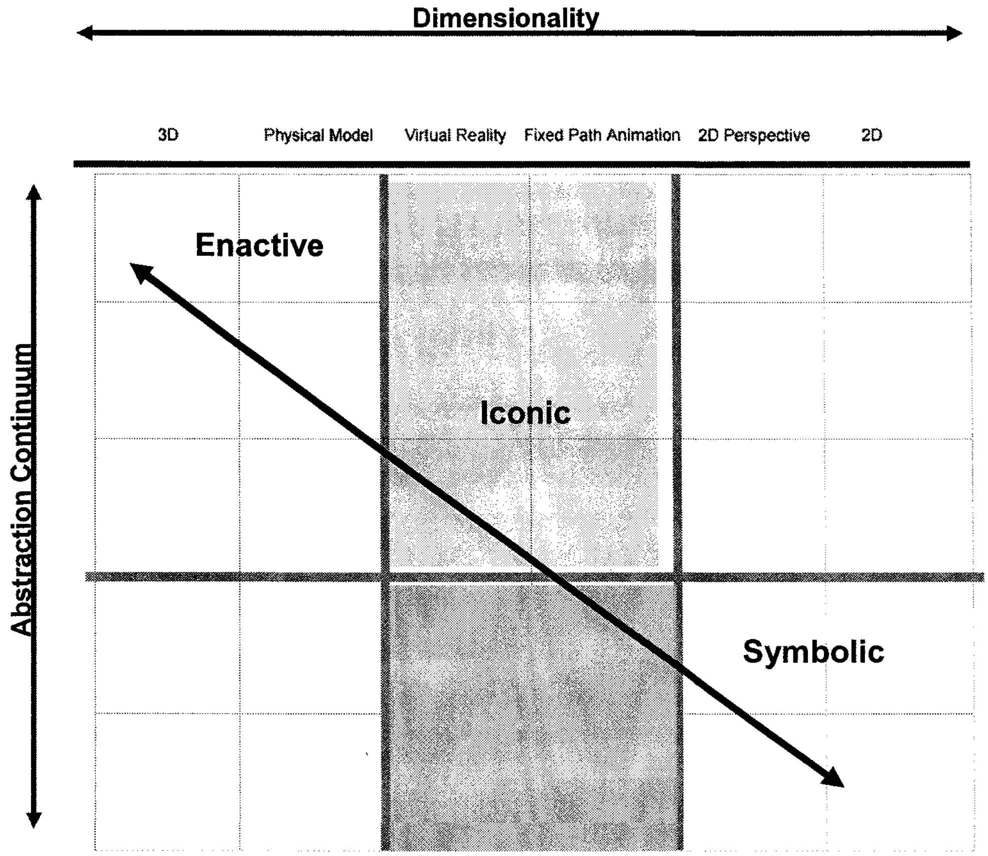

Figure 46: Taxonomic Model with Provisional Diagonal Dimension.

In particular it was felt to have value with regard to matching interfaces with different users' preferred learning styles, for example a stock market trader may find symbolic interfaces more engaging than mimetic interfaces. Further research would be necessary to confirm the significance of building in this dimension to the model.

The model has been featured in a paper written by the researcher for *Digital Creativity* journal[326] and was a central part of a keynote speech at the Design Council's Design in Business Week.[327] These peer review opportunities put the model to the test in terms of its communication value and presentation.

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[326] A copy of the paper can be found in Appendix 10.
[327] Cooper, A. *The Role of Three Dimensions and VR in Graphical User Interface Design.* Design in Business Week Keynote, 'Digital Media Design', Design Works, Gateshead, UK, 2000 [unpublished].

CHAPTER 7.0: DISCUSSION

This section will interpret the findings from Chapters 5 and 6 with a discussion of:

- The virtues and constraints of the VR medium as indicated by a cross-case analysis
- The matrix of communication as a strategic framework for the development of VR design
- Design recommendations and guidelines resulting from the research.

7.1 Discussion of the Results from the Case Studies

The objective of the case study research was to reveal the virtues and constraints of the three dimensional user interface in VR, through studying in depth practical examples undertaken in industry. The criterion for successful exploration was that commonalities would be found across cases, relating to analytic generalisation of a theory / list of virtues and constraints. To achieve this, each case study asked: What are the key functional and aesthetic characteristics of a three-dimensional user interface? A second question sought to relate this to existing two-dimensional interfaces by asking: How does the three-dimensional user interface differ from the two-dimensional user interface? These questions reflected the exploratory and descriptive nature of the research as outlined in Chapter 4. Possible rival theories included software or hardware technological determinism which would be the case if the results were not formed by the virtues or constraints of Virtual Reality, but rather biased by the particular software or hardware capabilities. This will be discussed in Section 7.1.2.2 on technological determinism.

Against a cross-matching methodology the following commonalities were found in the projects studied in phase two: interactive; fun and easy to use; intuitive and self selling; visual summary of complex information and relationships; appreciation of scaling; spatial arrangement of information and ability to choose different viewpoints. This list can be reviewed against the findings from phase one case studies as shown in Table 24.

Phase One Case Studies (tentative)	Phase Two Cross-matched (formative)
Virtues	Virtues
Interactive.	Interactive.
	Fun and easy to use.
Intuitive to a range of people.	Intuitive and self-selling.
Complicated or voluminous information.	Visual summary of complex information and relationships.
Information whose change in form is significant to our understanding of it (scale).	Appreciation of scaling.
Information which needs to be assimilated quickly.	
Information which is non-linear, e.g. hyperlinks, revealing structure (e.g. collaborative work).	
Relationships between entities or individuals, especially with regard to various vantage points for the viewer (reader).	Spatial arrangement of information.
Multiple viewpoints.	Ability to choose different viewpoints.
Constraints	Constraints
Abstract form difficult to read.	Difficulty in representing ideas with no concrete reality.
	Software tools difficult to use.

Table 24: Phase One and Two Case Studies: Cross-Matched Virtues and Constraints.

7.1.1 Comparison of Phase One and Two Case Studies to Reveal Virtues of the Medium

A direct comparison across phases of case studies is not valid for this research due to different selection criteria (as discussed in Section 4.5.2). However, some commonalities were evident as noted in the combined list below:

1. Interactive
2. Fun and intuitive: to a range of people
3. Illustrates relationships: between data, entities or individuals
4. Spatial arrangement of data: illustrate non-linear information, navigation and landmarks
5. Utilises scale: changes in form or relativity of scale
6. Multiple viewpoints
7. Visualisation of complex information.

These virtues are not exclusive to VR, for example television and multimedia can also be seen to be fun and intuitive, but they do correlate with findings from other research such as Erenay[328] and Sherman & Craig[329] to be key characteristics of the medium. Likewise, in the UK VR survey (1997) by the Advisory Group on Computer Graphics (AGOCG) UK practitioners and researchers perceived main benefits of VR to be Intuitive/naturalistic, diversity of audience and economic benefits.[330]

In particular, Sherman & Craig's recent book, Understanding Virtual Reality (2003), covers a lot of the ground investigated by this research and represents a significant and all-encompassing review of the state of the industry, filling a previous void of practitioner-led information. In the book Sherman's reference to communication studies further supports the area of study outlined in this thesis and where other commonalities exist they have been referenced in the text that follows.

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[328] Erenay, O. & Hashemipour, M. Virtual Reality in Engineering Education: A CIM Case Study [Online]. *The Turkish Online Journal of Educational Technology.* Vol 2, Issue 2, Article 8. April 2003. URL: http://www.tojet.net/articles/228.htm. [July 2004].

[329] Sherman, W. & Craig, A. Understanding Virtual Reality: Interface Application and Design. Morgan Kaufmann Publishers, 2003.

[330] Stapleton, L. J. & Costello, P. J., *A Survey of Virtual Reality Research in the UK 1997* [Online]. p.10. URL: www.agocg.ac.uk. [July 2004].

Interactive: The case studies in phase two noted consistently the 'interactive' nature of VR with the user gaining significant control. This fits with Sherman's description of VR's five core characteristics: intensive, interactive, immersive, illustrative and intuitive.[331]

Fun and intuitive: to a range of people: In addition to fitting with Sherman and Stapleton's descriptions as noted above, this virtue was also indicated by Fisher.[332] However, it reiterates a previous point made by the interviewee (Fisher) rather than providing new insight and can therefore only be seen to confirm previous assertions.

Illustrates relationships between data, entities or individuals: This was shown particularly in Concept 2010 and Sculptural Metamorphosis case studies. It also links to Sherman's 'illustrative' definition of VR as noted above.

Spatial arrangement of data: illustrate non-linear information, navigation and landmarks: This may indicate that VR lends itself to tasks that are inherently three dimensional,[333] or worlds where movement through physical space is important for example architectural walkthrough. This fits with a suggestion from Stappers et al, who consider that: "VR is a promising tool in application areas dealing with complex spatial problems."[334]

Within this, a key characteristic of Virtual Reality worlds was found to be the capability for the user to have significant control over their environment. In this way they can choose non-linear paths through the information displayed to them. Data navigation was found to be more of an issue than data visualisation, with landmarks being important. This was also noted by Fisher and Taylor Hendry.[335] In this respect other research has looked at landmarks, flying carpets, crumbs[336] and virtual CAIRNS[337] (A trail of virtual pebbles) to

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[331] Sherman, B. & Judkins, P. *Glimpses of Heaven, Visions of Hell: Virtual Reality and Its Implications.* Coronet Books, Hodder and Stoughton, 1993, p.156.
[332] Fisher, K. et al., Non-Verbal Guidance for Cyberspace Explorers. *British Telecommunications Engineering.* 14 (2), July 1995, p.131.
[333] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.416.
[334] Stappers, P. J., Gaver, W. & Overbeeke, K. *Beyond the Limits of Real-Time Realism: Moving from Stimulation Correspondence to Information Correspondence* [Online]. Delft University of Technology. URL: http://www.io.tudelft.nl/id-studiolab/research/pdfPool/2000/00StapEVRBeyo.pdf. [July 2004].
[335] Fisher, K. et al., Non-Verbal Guidance for Cyberspace Explorers. *British Telecommunications Engineering.* 14 (2), July 1995, p.131.
[336] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.229.
[337] Platt, P., & Willard, A. The Ramblers Guide to Virtual Environments. *The 3D Interface for the Information Worker,* IEE London, May 19, 1998, p.3/1.

allow users to track progress through a virtual space. In particular this research highlighted the 'reset the world' function as the most important tool for navigation.

Utilises scale: changes in form or relativity of scale: This was evident in Sculptural Metamorphosis and Concept 2010 (where shares were visualised as their attributes changed). Erenay's conclusions fit with sense of scale and studying complex interactions.[338]

Multiple viewpoints: All of the case studies showed the ability for the user to control the viewpoint, however in Call Waiting this facility was not felt to be important. This ability of VR to physically alter vantage point is also noted by Sherman and Craig.[339] VR has been characterised as giving significant user control and for allowing multiple participants.

Visualisation of complex information: This was indicated by Concept 2010, Call Waiting, Emotional Icons and Sculptural Metamorphosis. Here a benefit of this complexity was achieved through having more space on screen as also noted by Card et al.[340]

Also of interest, although only notable in one case, was the ability shown in Concept 2010 to visualise real-time data. This was also suggested by Sherman, who notes the ability of VR to manipulate time and space[341] and utilise a real time interface.[342]

These findings in themselves do not reveal significant novelty, but rather affirm the results from other studies or strengthen anecdotal practitioners' evidence. As discussed in Section 2.3.1, what is a benefit in one field may not be in another, making the virtues context-specific. In this respect, studies of virtues and the associated benefits of VR will need a significant volume of examples before more generic qualities will become clear. Where this research makes a contribution beyond other research is in drawing conclusions from

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338 Erenay, O. & Hashemipour, M. Virtual Reality in Engineering Education: A CIM Case Study [Online]. *The Turkish Online Journal of Educational Technology.* Vol 2, Issue 2, Article 8. April 2003. URL: http://www.tojet.net/articles/228.htm. [July 2004].
339 Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.89.
340 Card, S.K., Mackinlay, J.D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.633.
341 Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.50.
342 Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.415.

design practice and positioning these within both a theoretical and strategic context as discussed in Section 7.2.

It may be possible to infer from these virtues areas or design genres where the medium is inherently suited, for example three dimensional walkthrough of an architectural proposal may utilise multiple users, vantage points, scale and complexity. Although further research would be necessary to make clear connections between the medium's attributes and its suitability for different applications as this was not part of the research. Other studies have reviewed this and Earnshaw et al,[343] Rowley[344] and Sherman,[345] offer insights into some areas that are naturally emerging as the medium matures as noted in Section 2.3.2.

The research had anticipated finding the *unique* virtues of the medium, however the unique capabilities of the Virtual Reality medium have not been shown to be clear cut. Given the complex relationship between the medium and the message,[346] it is considered unhelpful to define VR's *unique* attributes as it narrows the definition down significantly to the point of being meaningless. In fact VR's uniqueness appears to come from a range of attributes in combination rather than one single defining virtue. Even down to the key attributes of interactivity and user control, one cannot see these as defining VR alone, as television is interactive, yet VR is more interactive. This makes a definition of VR more complex and prone to different interpretations as Sherman notes: "Because virtual reality is a *new* medium, its definition is still in flux. The researchers and users of VR naturally have their own points of view."[347]

[343] Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems*. Academic Press Limited, 1993, p.8.
[344] Rowley, T. Virtual Reality Products. In: Earnshaw, R., Gigante, M. & Jones, H. (eds.) *Virtual Reality Systems*. Academic Press Limited, 1993, p.45.
[345] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design*. Morgan Kaufmann Publishers, 2003, p.417.
[346] McLuhan, M. *Understanding Media, The Extensions of Man*. Routledge, 1995, p.9.
[347] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design*. Morgan Kaufmann Publishers, 2003, p.6.

7.1.2 Constraints of Virtual Reality Medium

From the case studies there are a number of challenges with the medium which can be broken down into two key areas of relevance to design:

- Representational issues
  - The wide availability of signs and their implications for design decision-making; in particular the role of the design process in VR development
  - Representing things that don't have a concrete real-world counterpart
  - Real-world and virtual-world brand compatibilities.

- Technological determinism
  - Poorly designed VR software tools, inconsistent interface
  - Coping with the low quality technologies.

7.1.2.1 Representational Issues

Virtual Reality as a language is made up of signs and symbols that are combined to present a message to the user. This language is formed either consciously or unselfconsciously by the interface designer, who must make choices about what to represent.

If we refer to Bolas description of different types of VR (in Section 2.5) and in particular the classification of design *with* virtual environments (the use of virtual reality to help solve a problem or invent something new) and design *of* virtual environments (the creation of completely synthetic environments, or virtual worlds), it is possible to describe the main activities undertaken by designers. [348] Firstly when designing *with* VEs designers are often utilising the software as a 'visualisation tool', as a means to an end. Whereas, in the design *of* VEs designers are building signs and representations in VR as a medium in its own right.

As discussed in Section 2.8, VR in design is widely used as a 'visualisation tool', for example in architecture and car design where the goal is to create the most real impression

[348] Bolas, M. Designing Virtual Environments. In: Loeffler, C. and Anderson, T. (eds.) *The Virtual Reality Casebook.* Van Nostrand Reinhold, 1994, p.49.

of the concept either by colour matching, form, highlights or surface texture.[349] Here VR might be used to test form-fit or operational issues such as users' interaction with controls. In these VR interfaces the subject matter (referent) is not designed using VR (transformed) but rather visualised or simulated (transposed). This process of visualisation takes the details from the real-world referent, either real or imaginary, and mirrors them (mimesis) where the ultimate goal is descriptive, as shown in Figure 47.

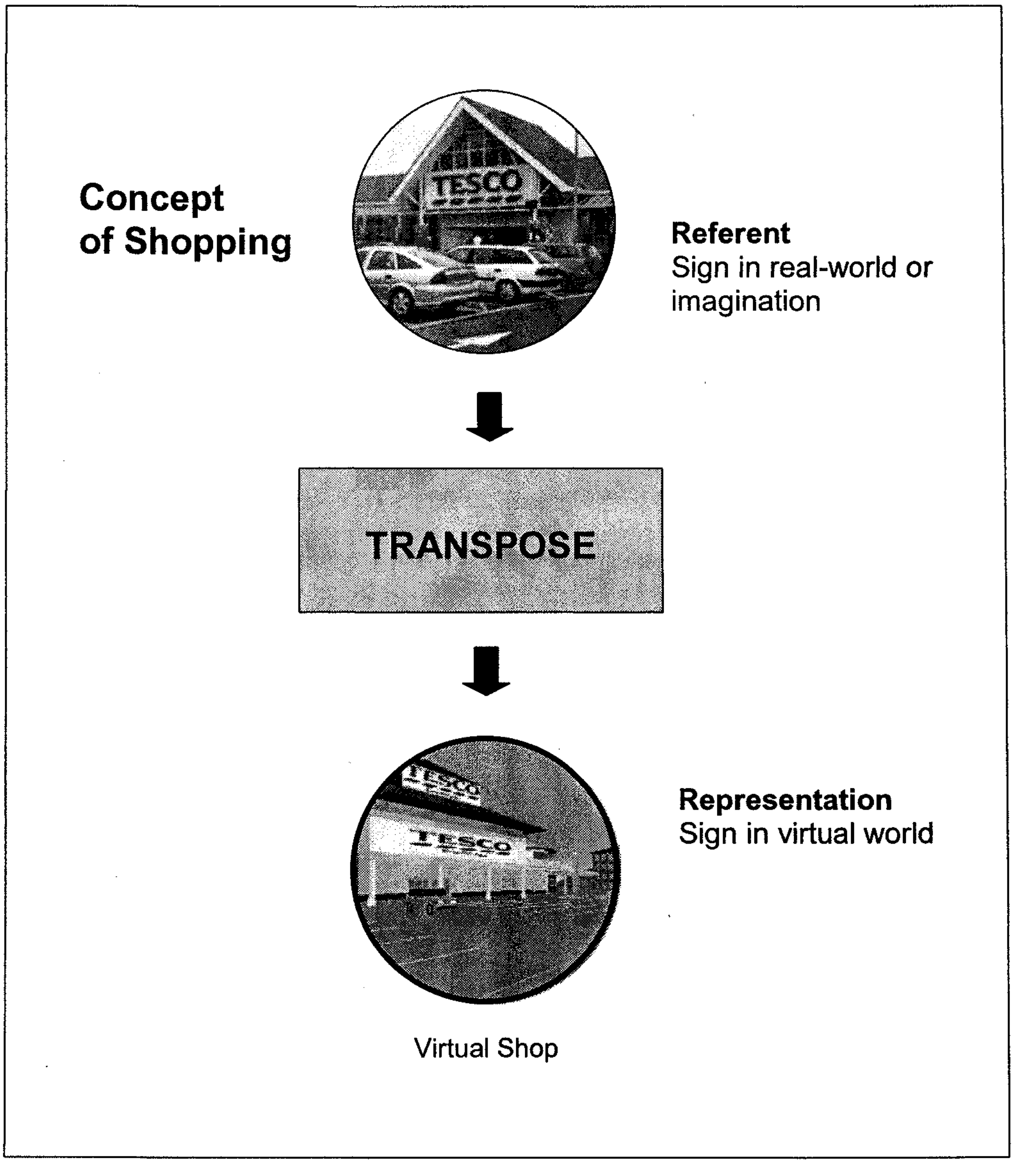

Figure 47: 'Visualisation' Tool - Design *with* VR for Descriptive Goal.

[349] Shields, R. *The Virtual.* Routledge, 2003, p.367.

In contrast, this research has looked at the design *of* VEs, where the designers are able to be more creative with how the referent is 're-presented'. Most of the case studies investigated fell into this category. Here, the biggest challenge for the designers was in choice of sign to represent a chosen concept, for example the use of a virtual laptop for non-computer users as discussed in Knowledge=Power case study (Section 5.4.4). In both phase one and two case studies the difficulty in representing abstract ideas or ideas with no concrete reality was expressed as a constraint, in particular in representing things which didn't have a real-world counterpart. As Fisher noted in the Call Waiting case study: "How on earth do you represent a call was the biggest thing."[350] In these examples the use of a design process becomes more apparent in making design decisions from a range of options. In the best designed VR examples, an appropriate design process can ensure that the virtual world is consciously designed rather than transposed from a physical reality without consideration. Here, the concept of design can be broken down into its parts. Hence, there is a process of de-signing (deconstructing the sign) and then re-signing – rather than re-designing (attaching new meanings or synthesising into a new form with newly attached meaning – invention or innovation). As noted by the breakdown in the following definition:

> "\De*sign" [imp. & p. p. Designed; p. pr. & vb. n. Designing.] [F. d['e]signer to designate, cf. F. dessiner to draw, dessin drawing, dessein a plan or scheme; all, ultimately, from L. designare to designate; de- + signare to mark, mark out, signum mark, sign. See Sign, and cf. Design, n., Designate."[351]

What occurred in case studies, such as 3D Retail, was a process of innovation that allowed the constraints of the problem to be moved through a process of de-construction and reconstruction or de-signing. In Figure 48 we see a virtual supermarket (bottom right) and a virtual shopping experience (bottom left). The outcome of this process is the positioning of the design in a new paradigm, moving from town centre retailing for the masses, to home-based interior designing for the individual. This reflects a broadening of the criteria where the user's needs were to purchase things, and changing technology removed the need to visit a retail shop. When working on the design *of* virtual environments the design process should be more evident in the development of solutions through the medium as outlined in Figure 48.

[350] Case Study Analysis - Call Waiting Q68 'Was it always clear what kind of visual representations should be used?' , Appendix 3, p.56.
[351] Dryden. *Webster's Revised Unabridged Dictionary* [Online]. URL: http://dictionary.reference.com. [June 2004].

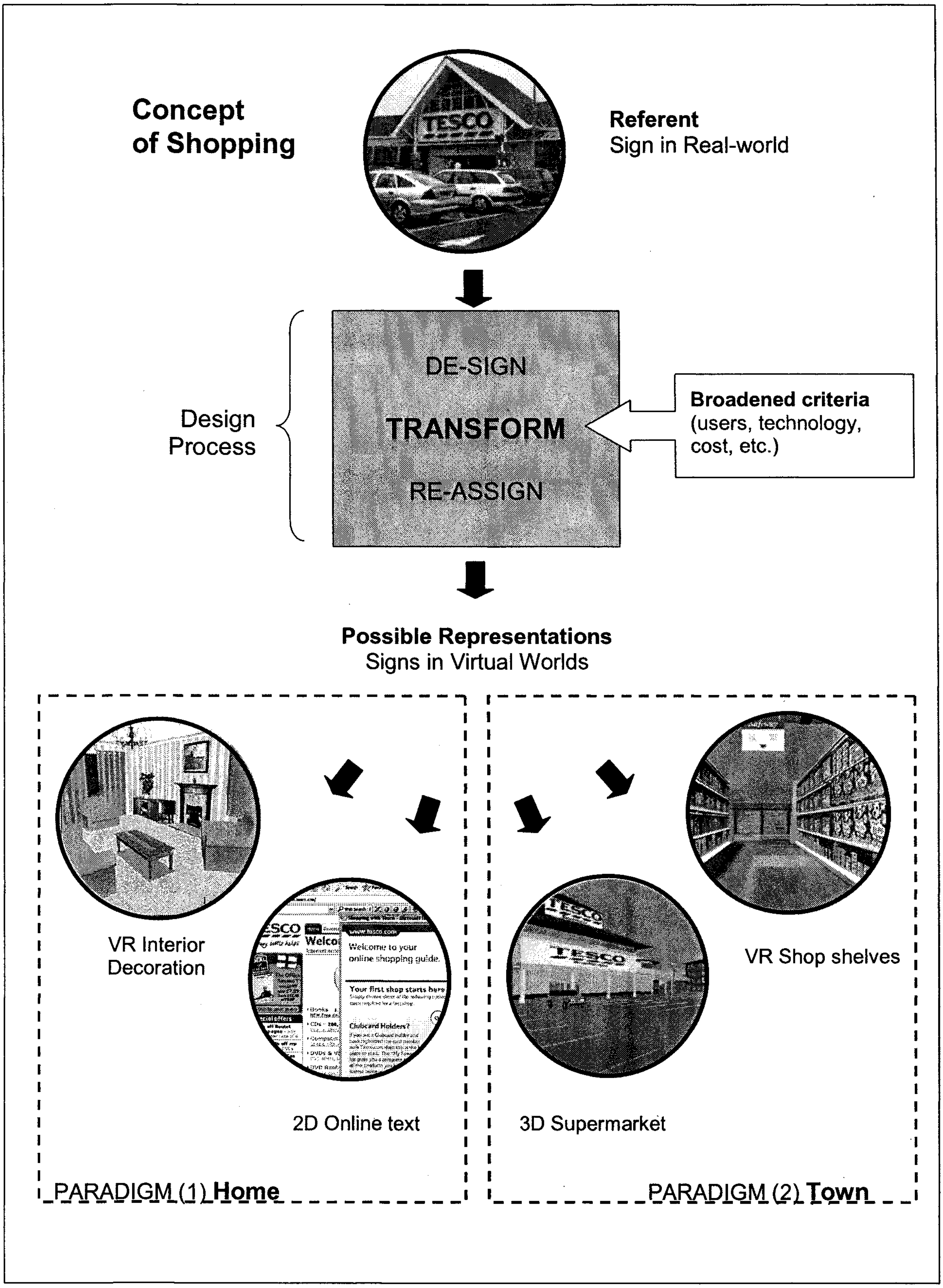

Figure 48: 'Design' Tool - Design *of* VR

Clearly, design is transformative in that it is based on the synthesis of disparate ideas into a coherent new form built from a range of considerations or constraints. As a process, design is about deconstructing a problem and reconstructing a solution, making it relevant to the development of VR. However, this process appears to be missing from many VR projects as noted by Stappers, "...even state-of-the-art academic and research VR environments can often be improved by good designers (e.g. graphic or product designers, architects) with a clear view of the user's experience and task."[352] This is acknowledged by Sherman in his recent book: "Unless you are just experimenting with VR to learn the medium, it is wise to approach the creation of a VR experience with good design practices."[353]

This deconstruction of a problem (de-sign) and reconstruction of a solution (re-assign) is closely aligned to the values of experience design, which is affecting physical world design practice. As Ardill suggests, an experience designer, given the job of designing a newspaper, will not simply consider the print or graphics, but will think about the idea of a newspaper and how and where it is used, which could result in a completely different solution as discussed in Section 2.8.2. In VR, an experiential approach means considering the medium's potential to portray things in new, user-led ways rather than merely re-producing existing realities. To achieve an experiential approach, the translation from one form to another should involve a design stage: i.e. to create a VR supermarket is to replicate reality, however to create a VR shopping experience is to understand users' motivations and needs and design an appropriate response. This is similar to Stappers' user-led 'information correspondence approach' as noted in the following quotation:

> "The information correspondence approach suggests that rather than trying to slavishly imitate stimulation, designers should focus on task requirements first, then information that guides these tasks, and finally on means of making that information accessible to the user. The solution may not be veridical, in that it may not be experienced as the 'real thing.' Nonetheless, it may well lead to better tools."[354]

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[352] Stappers, P. J., Gaver, W. & Overbeeke, K. *Beyond the Limits of Real-Time Realism: Moving from Stimulation Correspondence to Information Correspondence* [Online]. Delft University of Technology. URL: http://www.io.tudelft.nl/id-studiolab/research/pdfPool/2000/00StapEVRBeyo.pdf. [July 2004].

[353] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003 p.423.

[354] Stappers, P. J., Gaver, W. & Overbeeke, K. *Beyond the Limits of Real-Time Realism: Moving from Stimulation Correspondence to Information Correspondence* [Online]. Delft University of Technology. URL: http://www.io.tudelft.nl/id-studiolab/research/pdfPool/2000/00StapEVRBeyo.pdf. [July 2004].

Furthermore, broadening the criteria and creatively approaching the use of signs may reveal more opportunities, alleviating the problem of representation when there is no real-world counterpart, although further research would need to explore this.

In addition to the above, the case studies revealed similar findings to other research on metaphor and consistency. In particular, the importance of object permanence was noted in Call Waiting where objects needed to have 'paths' out of the field of view for the user to accept the metaphor, as also noted by Kay.[355] Likewise, the importance of the consistent use of attributes *within* a metaphor was raised. However, multiple metaphors were not felt to be a problem supporting the findings of Carroll et al on 'composite metaphors.'[356]

Finally, real-world and virtual brand compatibility issues were raised as predicted by the BT expert forum (see Section 5.8.7), for example when Laura Ashley felt the virtual environment did not fit its brand guidelines, even though it contained all of its prints and surface decorations.

7.1.2.2 Technological Determinism

The software was not found to constrain the concepts, as Fisher notes: "It was the ideas not the tool that was the problem."[357] However, it did affect the presentation of the design, with modelling having to be very basic to allow the machine to do quicker frames. This led to an aesthetic which was described by Fisher as 'minimalist', where the designer focused on the key attributes, or affordances, of a particular object in the VR space rather than generating it realistically. This was suggested to be like reverse engineering or value engineering the graphics from a use (affordances) point of view to minimise rendering requirements. This notion of affordances relates to the central tenet of Stappers' paper on 'Information Correspondence'[358] and would merit further investigation (as noted in Section 9.1.8). As an argument this further supports the perspective that efficient communication need not equate to realistic visualisation as discussed in Section 2.7.2.1. As Allen notes:

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[355] Kay, A. User Interface a Personal View. In: Laurel, B. (ed.) *The Art of Human-Computer Interface Design.* Addison-Wesley Publishing Company, 1989.
[356] Carroll, J., Mack, R., & Kellogg, W. Interface Metaphors and User Interface Design. In: Helander, M (ed.) *Handbook of Human-Computer Interaction*, North-Holland, 1993. pp. 67-85.
[357] Fisher, K. Case Study Analysis - Call Waiting Q23 'Would it have been possible to create the virtual world using different software?' Q23b) If so, would this have changed the design?
[358] Stappers, P. J., Gaver, W. & Overbeeke, K. *Beyond the Limits of Real-Time Realism: Moving from Stimulation Correspondence to Information Correspondence* [Online]. Delft University of Technology. URL: http://www.io.tudelft.nl/id-studiolab/research/pdfPool/2000/00StapEVRBeyo.pdf. [July 2004].

"VR is essentially a graphics medium and it should be remembered that good illustration, or graphics, or art, depends not on how 'realistic' an image is, but on how successfully it conveys its intended message."[359] This is more closely aligned to cartoon or caricature as noted by McCloud.[360] Similarly colour rendering was not well developed and this had implications where the design needed to be descriptive, for example rendering a realistic fabric pattern in 3D Retail. Given that much VR in design to date has been 'appearance' and 'presentational' this limitation has consequences when the desired outcome is descriptive (see Figure 47). However, this impacts less in the other case studies investigated as they were more exploratory in goal (see Figure 48).

The technologies associated with the tools also led to particular design results, this was most evident in the heavy reliance on clip art, clip objects and clip sounds across cases. The importance of the tools was previously noted by Laurel:

> "For designers and programmers, the empty space is filled with tools (hardware, programming languages, utilities) from which worlds will be constructed, and the nature of those worlds are constrained by the nature of the tools."[361]

Due to the significant investment in time necessary to build objects, often it was preferable for the designers to use pre-designed representations even when this was felt to be a compromise. A preference was even expressed for software that had large libraries of pre-built objects. Yet it also encouraged experimentation with unexpected bonus features allowing designers to develop things they hadn't anticipated.

Although the main criticism of VR was the poorly designed VR software tools and inconsistent interfaces, the Superscape software was also described as being designer-friendly in comparison to C++ allowing the designer more control over what was represented. Since the case studies took place there have been developments in VR modelling software, therefore further research would be necessary to confirm these findings.

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[359] Allen, K. et al. *Creating and Using Virtual Reality: A Guide for the Arts and Humanities* [Online]. URL: http://vads.ahds.ac.uk/guides/vr_guide/sect26.html. [July 2004].
[360] McCloud, S. *Understanding Comics.* Perennial, 1994, p.31.
[361] Laurel, B. Virtual Reality Design: A Personal View. In: Helsel, S & Roth, J. P. (eds.) *Virtual Reality: Theory, Practice, and Promise.* Meckler Publishing, 1991, p.96.

7.2 Discussion of the Communication Model

Designers often use an empirical approach to resolving images in their practice using previous portfolio examples as a precedent for future work. While this approach has clear advantages on a project-by-project basis when time is limited, it does lack a strategic aspect, which could reveal alternative opportunities in practice. This lack of a holistic approach encourages designers to look to the past. Consequently at the beginning of a project, this kind of approach could narrow the scope for creativity. There may be a number of reasons for this, either by client briefing, technological determinism or conventional approaches that dwell in known territory. Furthermore, designers may lack interest in theory when they do not perceive it to have a direct relevance to their practice. This was found to be the case at BT, with some designers lacking a language to describe some aspects of their interface design work. In response to this the research has proposed a communication model, or taxonomy,[362] to classify and categorise images in terms of theories of communication. As Berger notes:

> "The purpose of classification is to find relationships that are not immediately evident. Classification involves taking some collection or group of people or objects or events that have something in common and showing what they share. That is, we take a group related by some common attribute or attributes and break the group down further into mutually exclusive subgroups - depending upon what we want to find out."[363]

This model utilises examples of practice and case studies to highlight theories that can be applied to practice. The advantage of a taxonomy for designers is highlighted by Shneiderman: "Taxonomies facilitate useful comparisons, enable education, guide designers, and often indicate opportunities for novel products."[364] A key benefit of the taxonomy has been to create a mental model for designers to employ to support their decision-making during future projects. As noted by Card in Shneiderman: "Any theory

[362] "A taxonomy is a kind of theory. A taxonomy is the result of someone trying to put order on a complex set of phenomena; for example, a taxonomy might be created for input devices (direct versus indirect, linear versus rotary) (Card et al., 1990) tasks (structured versus unstructured, controllable versus immutable) (Norman, 1991), personality styles (convergent versus divergent, field dependent versus independent), technical aptitudes (spatial visualisation, reasoning) (Egan, 1988), user experience levels (novice, knowledgeable, expert), or user-interface styles (menus, form fill-in, commands)." Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.54.

[363] Berger, A.A. *Media Research Techniques.* 2nd ed., SAGE Publications Ltd, 1998, p.127-128.

[364] Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.54.

that could help designers to predict performance even for a limited range of users, tasks, or designs would be a contribution."[365]

In VR, examples of practice are generally grouped together regardless of their content. In contrast, this research explored the possibility of classifying VR projects to see if within the category, interfaces have different attributes. This follows from the discussion of the mimetic iconic interface and the post-geographic interface as illustrated in Section 2.7.2. Previously, VR had been considered as a dichotomous interface, either realistic or abstract. This research proposed a taxonomy to illustrate the case studies of practice against a semiotic framework. What has been described is a classification of the 3D virtual reality visual genre highlighting subtle nuances within the medium. From the communication models we can see that:

- Classification of the 3D visual genre with examples helps map the territory and reveal opportunities for future practice
- Iconic and symbolic design is a continuum rather than a dichotomy
- Psychological theories can be integrated into the model.

As with many taxonomies of practice, the model is by nature incomplete, with limited examples gaps are evident in the matrix reflecting the emerging subject matter.[366] As an outcome of the review by designers at the Centre for Design Research,[367] these gaps were felt to be as interesting as the content in the matrix highlighting areas for future practice.

The matrix developed here has similarity to Sherman's interpretation of McCloud's work, in particular with reference to a 'realism continuum'.[368] Yet there are important differences:

1. Sherman's work is based almost entirely on a review of American sources and case studies, whereas this work is based exclusively on commercial research work in the UK.

[365] Card, S. K. In: Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.54.
[366] Shedroff, N. In: Laurel, B. (ed.) *Design Research, Methods and Perspectives.* The MIT Press. 2003, p.156.
[367] Centre for Design Research Event, 27th October 2000.
[368] McCloud, S. *Understanding Comics.* Perennial, 1994, p.49.

2. The matrix develops the mimetic – symbolic 'realism continuum', yet also brings into the construct issues of dimensionality (i.e. 2D, 2D perspective, fixed path animated 3D, VR/Simulation, 3D) mapped against the following key considerations; modes of representation (i.e. symbol, index, icon), modes of engagement (i.e. enactive, iconic, symbolic), modes of learning, interactivity and narrative (i.e. linear, user defined).

Overall, Sherman's work can be seen to support the development of a communications based taxonomy. Likewise, Shields' 'categories of the real and possible' in *The Virtual*[369], illustrate a similar approach utilising a two-axes matrix to map virtual reality according to concrete and abstract terms, as shown in figure 49.

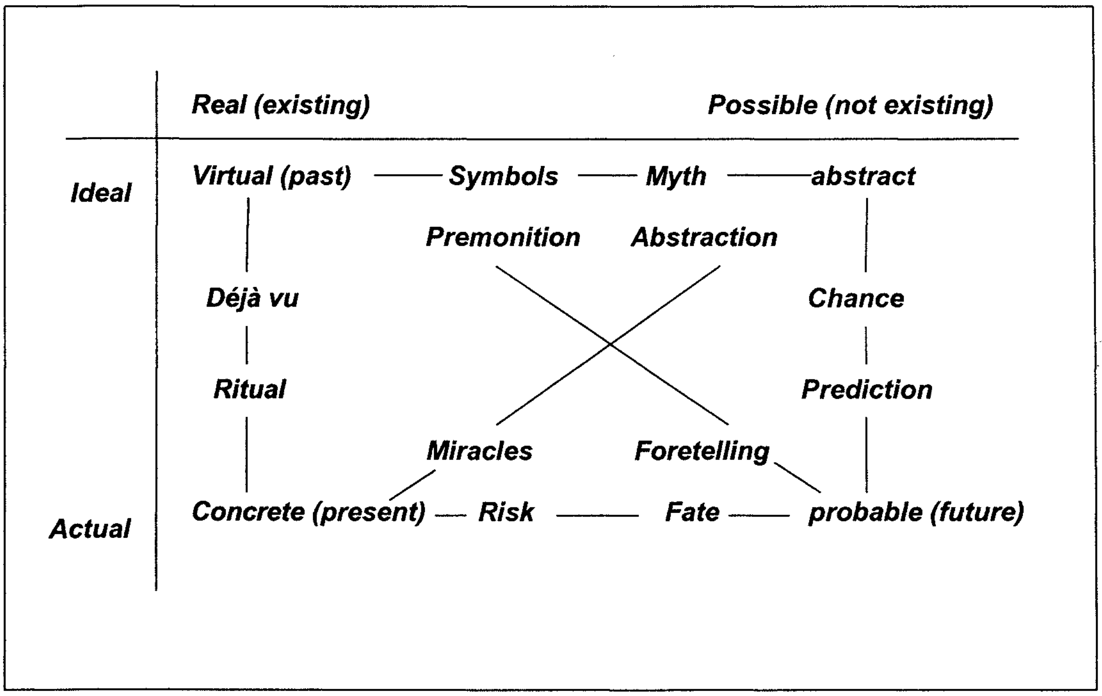

Figure 49: Figures of Speech and Movement between Categories of the Real and Possible. From Shields, R. *The Virtual.* Routledge, 2003, p.34.

In line with recent suggestions by Sherman & Craig, and Sheilds, the taxonomy presented by this research makes explicit the nature of the differences *within* the digital three dimensional interface. However, the value of this research has been the integration of 'case studies' of practice, as well as positioning VR contextually in relation to other modes of representation (2D etc. as noted in point 2 above). It is considered that this will enable

369 Shields, R. *The Virtual.* Routledge, 2003, p.34.

designers to incorporate the theories of communication studies more readily in their practice, although further evaluation would be necessary to confirm this.

Additionally, the matrix has highlighted both the different applications of design, and areas where language is inconsistent. For example, VR in design is often used to visualise something, usually an artefact or environment. When designers talk about 'visualising' according to terminology outlined in the literature review, they are often describing 'simulation' where the representation is at the mimetic end of the 'reality – abstraction' continuum (see Section 2.7.2).

7.2.1 Benefit of an Iconic-Symbolic Continuum for Design

From the matrix of communication we can see that the concept of a dichotomy between 'real' and 'abstract' is unhelpful in developing an understanding of the medium where there are far more subtle nuances. In design and knowledge terms the mimetic interface can be seen as a constraint on the creative use of the medium. Although it seems clear that the development of modes of representation 'beyond' the iconic requires users to develop new knowledge and associations, such representations may be aligned to longer term user-centred goals, where the ultimate goal is new knowledge. As Stappers notes: "The basic problem of the realistic aim is that it puts an objective world first, the user's experience, his tasks, and the information he needs for those tasks second."[370] Although some psychologists and philosophers suggest that we are fundamentally metaphysical and need to use the real-world as a reference within the computer environment, this does not exclude exploration into more abstract iconography combined with clear user narratives. Furthermore, in the model it was found that moving from iconic to abstract holds meaning whereas going the other way doesn't, suggesting that the order in which signs are presented is important to users.

A final example of practice which has relevance for this research by highlighting the implications of representing things at different points along the iconic-symbolic continuum is Loizides Empathic Visualisation Algorithm (EVA). This research project at UCL shows the visualisation of complex data in a naturalistic form (See Figure 50).

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370 Stappers, P. J., Gaver, W. & Overbeeke, K. *Beyond the Limits of Real-Time Realism: Moving from Stimulation Correspondence to Information Correspondence* [Online]. Delft University of Technology. URL: http://www.io.tudelft.nl/id-studiolab/research/pdfPool/2000/00StapEVRBeyo.pdf. [July 2004].

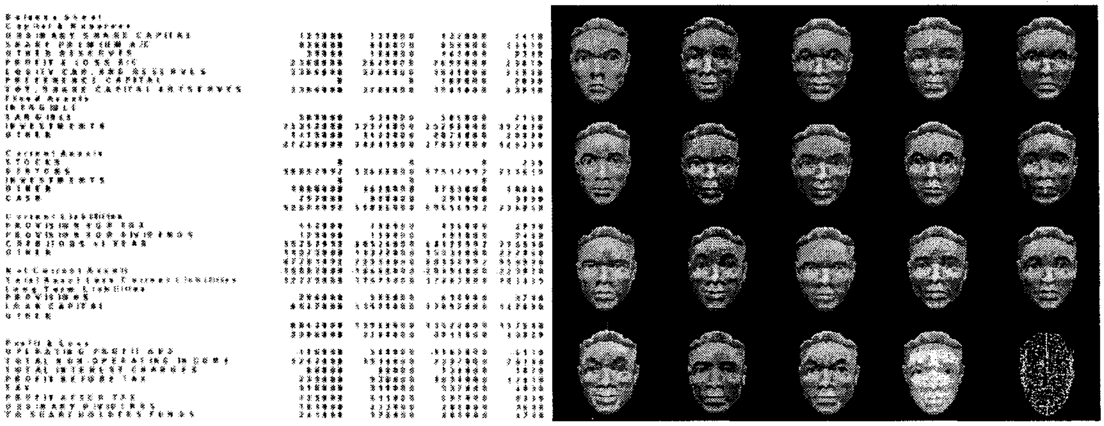

Figure 50: The EVA System (UCL).

Here, the project translated the complex financial information (symbolic) into a visual form (iconic) which was considered to generate a 'hardwired' response in users based on real-world experience. As Loizides and Slater note:

> "Suppose that each of these somehow represented the overall financial state of a company, in which ones would you invest? Suppose each one represented the global data representing the credit-worthiness of an individual who had applied for a loan, to which ones would you grant the loan?"[371]

Here, translating between media types and dimensionality has had an impact on the communicability of the information.

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[371] Loizides, A. & Slater, M. *The Empathic Visualisation Algorithm: Chernoff Faces Revisited.* [Online] Department of Computer Science, University College London. URL: http://www.cs.ucl.ac.uk/staff/a.loizides/218.pdf. [June 2004].

7.3 Discussion of the Integrated Outputs of the Research

Four key outputs have been developed through the research namely:

1. A list of virtues and constraints of VR derived from the research case studies (Table 24)
2. Communication Model: A taxonomy identifying VR opportunities in relationship to other media (Figure 43)
3. Two diagrams illustrating possible tactical approaches to designing VR:
    a. 'Visualisation' Tool - Design *with* VR (Figure 47)
    b. 'Design' Tool - Design *of* VR (Figure 48)
4. A cross-cutting issues template for framing the research questions and results as an outcome of the literature review (Table 5).

The value of these integrated outputs lies in revealing opportunities for designers by illustrating both tactical and strategic approaches to designing for VR (discussed in Section 7.3.1). In particular, they have sought to codify both tacit design knowledge (based on practitioner insights) and theoretical concepts (based on the literature review and expert forum findings) into theory-building models to be applied by designers. These outputs in combination form a toolset for designers to balance theory and practice against short term and long term needs. In practise this could encourage a deliberative approach on the part of the designers, enabling them to make conscious decisions about their motivations and actions at given times in the design process. To put this in context, many models of the design process exist and a typical approach to their intended use is to apply them iteratively, across several stages, to encourage both divergent and convergent thinking. The researcher has been involved as part of a team of design strategists in the development of a design process model at the Design Council as shown in Figure 51. This model has been developed to generically describe the process for designers according to four stages of designing namely; discover, define, develop and deliver. Although the Design Council acknowledges that other descriptions of the process exist, as the national authority for the promotion of design, the Design Council endorses this as a core tool for describing design activity. This model has been used generically to position the outputs of this research project and bring them into relationship. In this process, the first two phases (discover, define) can be considered to be strategic problem identification, whereas the latter two stages (develop, deliver) are more tactical problem solving.

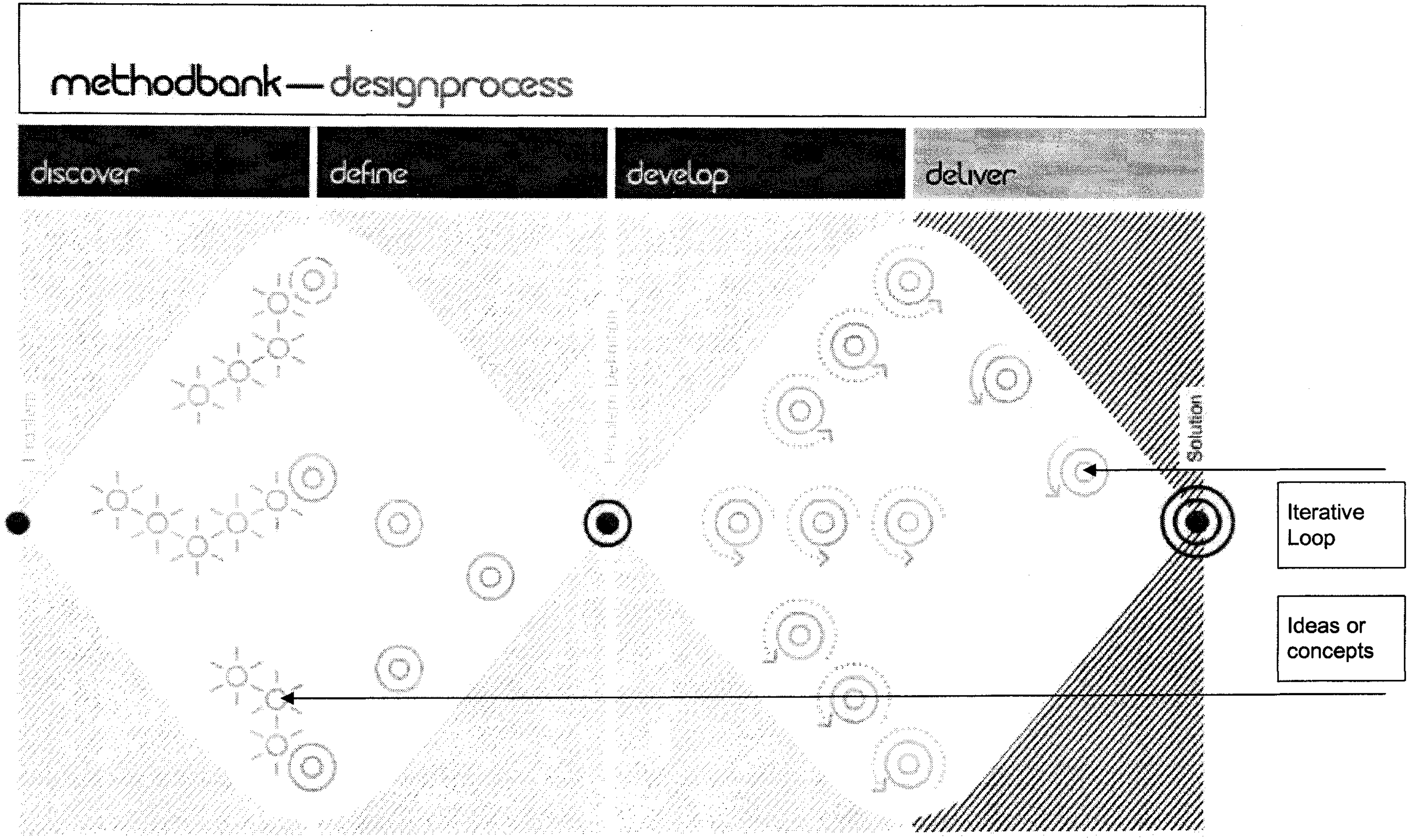

Figure 51: Design Council Method Bank – Design Process (Copyright Design Council)

If considered in relationship to the design process in Figure 51 the research outputs appear to lend themselves to different phases as noted in Table 25.

		Design Process			
		Problem identification (strategic)		*Problem solving (tactical)*	
	Outputs	**Discover**	**Define**	**Develop**	**Deliver**
Strategic	1. Communication model mapping opportunities across media	*Where are the opportunities beyond existing examples of practice?*			
Strategic	2. List of virtues and constraints of VR		*When to use VR and when to use other media?*		
Tactical	3. Two diagrams illustrating possible approaches to designing VR			*How to approach virtual designing?*	
Tactical	4. Cross-cutting issues template containing practitioner advice on key issues e.g. use of metaphor				*What elements should be considered in designing VR?*

Table 25: Outputs in Relation to Generic Design Process with Hypothetical Design Questions.

7.3.1 Potential Decision Making Points when Designing VR

In considering a design approach using the outputs from the research several hypothetical design questions highlight the different potential decision points of the strategic and tactical models. These are summarised in table 25 above and below as potential scenarios.

Where are the opportunities beyond existing examples of practice? This kind of question might arise during a discovery phase of work. At this point in time an overview of the possible design space would help indicate the kind of areas that might be valuable to focus the designer's work. The Communication model mapping opportunities across media would allow a designer to consciously consider the big picture at this time by looking at the implications of different media choice as well as how real or abstract the interface might be. Furthermore, if the learning modes (Figure 46) were integrated at this stage the implications on users' preference could be discussed.

When to use VR and when to use other media? This question might arise during a problem definition phase of work (discover-define) before a definitive brief is written or concepts and solutions are generated. At this point a list of virtues and constraints of VR derived from the research case studies would help indicate the types of design project that are suitable for designing in VR. For example, if interactivity and spatial arrangement of data were likely requirements, VR might be seen to be particularly suitable. It is important to note however, that although this research sought to find out unique benefits and constraints of VR, these were not found (As discussed in section 7.1.1) and as such the virtues indicated as an outcome of this research are derived from the case study sample and may have limited value in other contexts.

How to approach virtual designing? This question relates to a more tactical choice of selecting an appropriate approach to design development. At this point the diagrams illustrate the implications of two possible approaches: 'Visualisation' Tool - Design *with* VR for a Descriptive Goal or 'Design' Tool - Design *of* VR.

What elements should be considered when designing VR? The cross-cutting issues template both indicates the different considerations that might be valuable by topic as well as providing a vehicle for containing practitioner advice on key issues as a framework, when used to capture the findings from the case studies. This would have a value at all stages of a design process and might also be used as a reflective tool to capture information about an interface after a project has finished. For example, what software was used, how the metaphor was deployed and who the users were.

In combination these tools go some way towards providing designers with a wider framework for considering designing in VR. This strategic perspective should enable designers to consider opportunities and approaches that may not be apparent through existing practice. This outcome fulfils the research aim of adopting a wide frame of reference to gain a strategic understanding of the factors influencing the design of Virtual Reality and highlight the opportunities presented by the medium (as noted in Section 8.2).

CHAPTER 8.0: CONCLUSION

This research focused upon the way that different media bias the production of meaning during communication, and it set out to understand the design opportunities presented by the emerging medium of Virtual Reality. It looked at the types of considerations that govern the use of signs in virtual environments and how designers could be assisted in making appropriate choices in their design practice.

By adopting a wide frame of reference, the aim was to gain a strategic understanding of the factors influencing the design of Virtual Reality and highlight the opportunities presented by the medium. The objective of the research was to find out what the virtues and constraints (communication codes) of Virtual Reality were, as a basis for proposing tentative guidelines about the most appropriate design and use of representation for the medium.

The main output is a framework for considering the relative merits of particular graphics within a broader strategic context. This framework has been developed for interface designers to explore the characteristics of 3D image in Virtual Reality interface as a means of communicating knowledge through visual systems of representation. It has aimed to make alternative approaches to design content explicit from a strategic point of view.

The subject area is new with much research to-date being approached from an empirical or technologically determined standpoint. Whereas, this research has focused on a human communication-centred approach to provide a strategic framework form which the medium can be considered. Furthermore, the intention of this research has been to facilitate design practice by translating often heavily theoretical material into a model for use by designers.

8.1 Summary of Conclusions

This is a thesis on the use of signs and representation in the design of Virtual Reality projects to improve the designer's strategic understanding of the medium. The main points and deliverables are presented below with relevant cross references:

1. Virtual Reality design is very early in its evolution and does not currently fulfil its full potential as a medium for communication. Existing research and practice in VR is dominated by computer scientists and typically lacks a design approach (s.2.8, s.7.1.2.1 & s.9.1).

2. Designers utilising VR were predominantly using it to visualise and test real-world objects as part of the design process e.g. car design (Sections 2.7.2.1). Many designers working in this field have taken an empirical approach without reference to guidelines or theory (s.2.9 & s.7.2).

3. The language and terminology used in VR is in flux with many designers lacking descriptive terms to identify their practice (s.2.7.3, s.2.9 & s.7.2). Designers often refer to visualising and simulation as one category rather than as opposites (s.7.2).

4. The attributes of the Virtual Reality medium are context-specific and therefore varied (s.2.3.1 & s.7.1.1). Previous research has looked across sectors to draw conclusions about the potential of the medium based on practitioners' perceived benefits rather than actual benefits.[372]

5. This research has documented in detail a design approach to the development of VR undertaken at BT and in design consultancy. From this we can see the virtues and constraints of the medium for this sector (s.7.1.1). These virtues were found to be in its:

- Interactivity
- Fun and intuitive qualities for a range of users
- Illustration of relationships between data, entities or individuals
- Spatial arrangement of data illustrating non-linear information, navigation and landmarks

- Utilisation of scale: changes in form or relativity of scale
- Multiple viewpoints
- Visualisation of complex information.

The constraints were found to be around representational issues (choice of sign) and technological determinism (poorly designed VR software tools, inconsistent interfaces). Until sufficient examples of practice broaden the subject matter, generalised virtues and constraints of VR offer limited insight beyond the immediate context.

6. As an outcome of the case studies it was found that the design approach undertaken at BT allowed the development of representations which were not merely transposed to VR but rather designed for the purpose and users (s.7.1.2.1). It was recommended that for design of virtual environments, signs be deconstructed and transformed to enable creative solutions to be developed (Figure 48). This was felt to add significant benefits over transposing signs, as is the case with more descriptive VR projects (Figure 47).

7. Technological determinism was not found to play a significant role (s.7.1.2.2), although the widespread reliance on clip objects limited creativity. The research therefore recommends that instead of providing pre-built clip objects, software designers make tools to make building objects easier.

8. In order to improve the practice of VR design, a strategic approach was felt to be necessary to move beyond the dichotomy of real versus abstract, to align VR projects to users' communication needs (s.7.2.1). The new approach which is adopted in this thesis is based on first investigating the nature of communication and then integrating this theoretical approach with design practice. The resulting media matrix begins to do this by integrating users' preferred perceptual styles with VR cases. This model of communication reveals VR development to fall on a continuum rather than a dichotomy of 'iconic' or 'symbolic'. Finally, this matrix demonstrates potential areas for future design practice in non-iconic interface.

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[372] Howard, T. L. J, et al. 1995 Survey of Virtual Reality in the United Kingdom, Prepared for the Advisory Group on Computer Graphics, 1995 [Online]. URL: www.agocg.ac.uk. [May 2004].

8.2 Attainment of Objectives

The success of the deliverables can be measured by re-visiting the original research objectives detailed in Section 1.4:

Aim: By adopting a wide frame of reference, the aim was to gain a strategic understanding of the factors influencing the design of Virtual Reality and highlight the opportunities presented by the medium. *The preliminary inter-disciplinary research into communication studies, semiotics and HCI was completed satisfactorily and provided a solid foundation for the thesis. Beyond this the value of the research has been in documenting the challenges facing designers of VR and in revealing both opportunities and approaches through strategic and tactical models.*

(O1) The identification of key characteristics of the Virtual Reality medium, to facilitate design decision-making. *This objective provided a focus for gathering evidence through the case studies and provided a link between the existing practice and new opportunities. This is evident in the discussion of the correlation of the findings with the latest thinking in the field (Chapter 7).*

(O2) To provide designers with a framework for considering the relative merits of particular graphics within a broader strategic context. *This objective constituted the contribution to knowledge and sought to add value to the case study descriptions. A number of practical outputs were produced, the main one being the matrix of communication bridging theory and practice. Additional outputs included the identification of two approaches to practice and the issues template as an outcome of the literature review. Collectively these outputs demonstrate a strategic approach to designing for VR and underpin the achievement of the aim of the research.*

A number of key questions were identified which would specifically address the aims and objectives.

Primary Questions:

(Q1) What is the role of the three dimensional image in Virtual Reality?
(Q2) Can we use an understanding of other media to gain an insight into what Virtual Reality has to offer?
(Q3) What contextual issues surround this new medium?

(Q4) What might its benefits and constraints be?

Secondary Questions:

(Q5) Will it open up new knowledge?

(Q6) What are the implications of not addressing this?

(Q7) How should this issue be pursued in the future?

(Q8) What visual attributes are appropriate for three-dimensional interface and is there value in moving beyond the convention of a mimetic interface?

The success of the objectives set can be shown, partly, through completion of the overall aim which was to gain an understanding of the factors influencing the development of communication in Virtual Reality and the problems inherent in this context.

8.3 The Strength of the Research

The strength of this work has been in the juxtaposition of the theoretical approach with the practical qualitative case studies. Here the collaboration with BT allowed the use of advanced case studies from a business context and provided insights into real projects undertaken in industry. The design-led, often ambitious examples featured in the case studies represent a unique insight into the potential capabilities of the medium. In this respect the ability for the researcher to spend six months in house at BT developing the case study approach and analysis in context, added significantly to the quality of the case study investigation.

Likewise, the support of the Centre for Design Research and Design Research Society, in organising colloquia and other events to develop the research themes has added theoretical expertise and helped deepen the insights of the research. Finally, the longitudinal nature of the study with several reflective loops has offset some of the changes in technology in a fast-paced industry.

This research differed from previous research, discussed in Chapter 2, in the following key respects: Firstly, it was looking at the research from a designerly standpoint, with the expressed intention of 'translating' often very theoretical information into a useful model to be applied when designing or evaluating an interface. Secondly, it took a broader, more theoretical approach, using communication studies and in particular semiotics to identify the virtues and constraints of Virtual Reality, to provide a descriptive insight into the process of communication in this new medium. Finally, it applied a more rigorous methodology in contrast to the empirical work undertaken within the commercial arena and at BT.

8.4 Summary of the Key Contribution

Overall, the value/contribution of the thesis is as follows:

• Identification of the virtues and constraints of the VR medium.

The relationship of different signs and their virtues and constraints aims to improve the designer's understanding of the medium and could lead to further research looking at the link between virtues and application.

• Presentation of a model illustrating VR examples from a communication perspective.

By illustrating design content within a strategic, communication-centred framework, the research has created a mental model for designers to employ to support their practice. Shneiderman suggests taxonomies facilitate useful comparisons, enable education, guide designers, and often indicate opportunities for novel products.[373] Research by Card notes that any theory that could help designers to predict performance even for a limited range of users, tasks, or designs would be a contribution.[374]

• Development of the understanding of design-led VR case studies highlighting trends in empirical practice in HCI.

The semi-structured interview raw data in Appendix 3 documents VR design practice, from which the research has been able to indicate key recommendations for future opportunities.

• Identification of an alternative approach to developing signs in virtual worlds.

This description is developed through reflection on the case studies and has resulted in two models of design development (Figures 47 and 48). These highlight the different approaches to design content in VR, in particular the merit of transforming signs (de-signing) over transposing signs (mimesis).

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[373] Shneiderman, B. *Designing the User Interface: Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.54.

[374] Card, S, K. In: Shneiderman, B. *Designing the User Interface: Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.54.

8.5 Limitations

Although industry links have been a key strength of the research, a resulting limitation of the work could be seen in the completion of phase two case studies exclusively from BT. Furthermore, due to time constraints, the semi-structured interviews only interviewed one person on the project therefore could be open to criticism for being overly biased by individual opinion. This was minimised, through a thorough methodology utilising triangulation of other data and the completion of a number of interviews over time. On reflection, should the questions be re-run with other interviewees it would be important to consider the length of the interviews, which were up to 4 hours, and the positioning of key questions during this time frame to ensure the interviewee was able to give the best response. As such, further case studies or interviews with other participants would strengthen the results.

A second limitation may lie in the duration of the research, being undertaken over several years, which could make some of the case studies dated and have an impact on the technologies presented. Consequently the case studies may not in themselves represent the current state of the industry, but have been put into perspective through the length of the study. Although the longitudinal study has allowed for staged reflection on a fast-changing industry, further studies utilising recent software, would strengthen the content of the thesis.

A final point relates to the applicability and dissemination of the research. One of the key aims of the research was to adopt a wide frame of reference utilising theory from different subject expertise which is a key benefit of research. This has been achieved, although as a consequence of the inter-disciplinarian nature of the subject, systematic integration of the findings is harder to achieve (as noted in Section 3.1). The breadth of the subject area may contribute to a difficulty in disseminating the work as the subject lacks a community of design researchers. In contrast the extensive network of researchers in the field of HCI is not the target audience, yet represents a likely dissemination group from a research perspective. However, much work remains. A full mapping of the matrix with other examples would help, as well as evaluation of the framework with different practitioners, although it is believed this did not compromise the validity of the findings due to the rigour of the methodology.

9.0 RECOMMENDATIONS

9.1 Further Work

Although value exists within the research presented in this thesis, much work remains to document and compare the attributes of VR for designers. Until such time that there is a significant body of work in practice, the findings will be biased by the limited real world examples undertaken to date in various industries. Additionally, the approach taken by designers can mask the potential of the medium as noted by McLuhan.[375] As such a broadening of examples in time will provide a wider range of design responses to the medium from which to highlight additional avenues for investigation. This thesis highlights a starting point, a space where more research needs to be undertaken in order to make alternative methods of 'understanding' and designing for 3D interface explicit.

Further work could include a greater focus on the design content and user, as much work on VR to date has been focused on technologies, computer science and artistic exploration. Pantzar[376] describes this as domesticating technology with designers acting as a bridge between art and science. This division of territory can be illustrated in Figure 52.

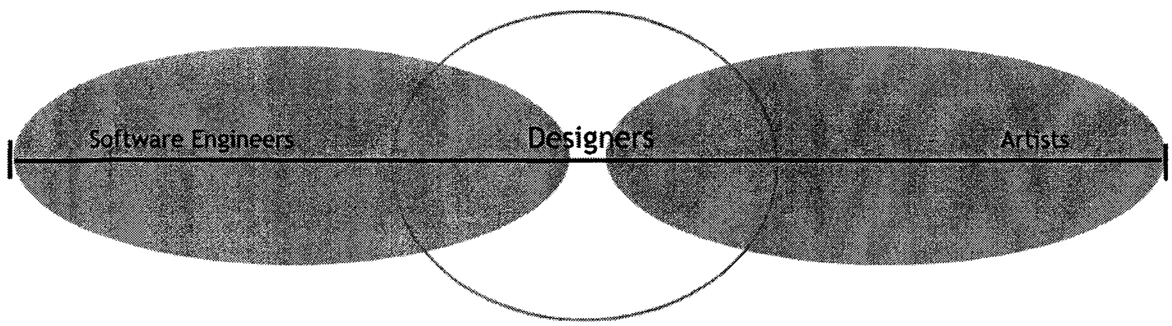

Figure 52: Mapping Artistic and HCI Activity and Highlighting Design 'Gap'.

[375] McLuhan, M. *Understanding Media, The Extensions of Man.* Routledge, 1995, p.9.
[376] Pantzar, M. Domestication of Everyday Life Technology: Dynamic Views on the Social Histories of Artefacts. *Design Issues,* 13(3), Autumn 1997, p.53.

The field is dominated by computer scientists and artistic exploration with little design input. However, as shown throughout this thesis, there are a significant number of design opportunities. As an outcome of this research the following design opportunities could be advantageous for exploration:

- The importance of taking a design approach rather than a technologically determined approach
- Appropriate application of a user centred approach, with the designer as a 'reader'
- The potential for sonic design
- The suitability of VR software as a design tool
- The ability to represent mental models or visualise intangible concepts.

With the exception of games design and the automotive industry, the design process has been largely ignored by 'developers' of virtual worlds. This has resulted in very few examples of user-centred, aesthetically pleasing VR. The design process is poorly represented in computer science research. In particular, this has consequences for: appropriate user centred design, aesthetic qualities of VR and the properly planned and iteratively developed solutions. Several research streams made visible in this thesis may continue this ongoing development.

9.1.1 Research into the Paradigmatic Nature of Design Process

Several of the case studies, notably 3D Retail, were able to switch paradigms through the design process by deconstructing the problem and presenting a solution from a different standpoint or context. Here, as discussed in Section 7.4.1, rather than representing the reality of a particular paradigm e.g. shopping, it was able to generate a new paradigm through looking at user requirements. This is achieved through the paradigmatic process of generalisability, as noted by McCloud[377] and Frutiger[378] as you move through from iconic to symbolic and back (see Figure 13). Further research looking at this process of deconstructing signs in VR would be of value.

[377] McCloud, S. *Understanding Comics.* Perennial, 1994, p.31.
[378] Frutiger, A. *Signs and Symbols. Their Design and Meaning.* Studio Editions, 1989, p.179.

9.1.2 User Centred Design and Co-authorship

During the development of communication concepts the designer was considered to act as the reader. Here, the designer acts as the interpreter of the sign on behalf of a chosen audience. It was felt that most designers perform this role naturally as a consequence of them actually being a member of the intended audience. In such instances the designer often ends up designing for themselves. It was felt that if the different interpretants (alternative readings) could be more apparent then the designer could more sympathetically and accurately represent the desired audience. Furthermore the user has significant control in the virtual environment and can be seen to be a co-author of the experience as Sherman calls creatorship.[379] This suggests that research into VR as a tool for participatory design could reveal some interesting areas for enquiry.

9.1.3 Design of Objects in VR – Virtual Semantics

Significant research has been undertaken into avatars, presence and human representation in VR but very little into the objects which fill the space. As industrial design covers the manifestation, product semantics, usability, aesthetics of objects in the real world, it seems strange that this is neglected in the virtual world. Here we see exemplified design's role as the missing link between technology and art.

9.1.4 Potential of Sonic Design

Sound was found to play a vital role in the virtual world, yet the designers had initially overlooked this. In particular, sound was felt to be valuable as a form of navigation and to enhance the believability of the immersive environment. Gaver et al have also described the power of sound in an interface.[380]

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[379] Sherman, W. & Craig, A. *Understanding Virtual Reality: Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.50.

[380] Gaver, W. The Sonic Finder, An Interface that Uses Auditory Icons University of California, San Diego and Apple Computer, Inc. *Human Computer Interaction,* 4(1) Special Issue on Non Speech Audio, 1989.

9.1.5 The Suitability of VR as a Design Tool

In addition to the use of VR as a visualisation tool, as is the case in automotive design, some scope may be presented in utilising VR as a design tool. Fisher notes that as a process, the use of VR software tools was found to be relevant for designers where they could make changes easily and use an iterative approach producing animations quicker than other animation software. Benefits described included speed of production, flexibility to solve problems, smaller file size than animation, design control over the results by the designer rather than via a programmer, and ability to make lots of changes easily, therefore making the technology suitable for highly creative and iterative work.

9.1.6 Extension of the Model into New Areas

The matrix of communication could be extended to convey further information, for example to overlay:

- Time: representing the emergence of different media in the model i.e. from the Renaissance to present day
- Technique: illustrate different media e.g. photography, computer, pencil, and paint
- Psychological preference: building on research by Bruner into personality and learning modes, for example the link between designers and enactive learning styles
- Further analysis of the virtues of 2D media.

There may also be value in looking in other narrative-driven VR sectors e.g. games design.

9.1.8 Virtual Affordances: Function and wear in VR as indicators of meaning

In the case study Concept 2010, the designers also experimented with an interface entitled 'grubby world' in order to show that when things get used a lot they get grubby and to raise the concept of 'burnt out icons.'[381] This is counter to the usual 'Swiss world' approach where objects in a world have an air of perfection. The issue of function is once again raised, as its closely associated attribute of use or wear is attributable to its functionality. Thus the information or objects presented in the real world contain meta-data about use through wear and aging. It may therefore be possible to accord suitability of a sign to a particular medium, and this notion has similarities to Gibson's use of the term affordance.[382]

9.2 Reflection

On reflection I am quite satisfied with the body of research. The extensive planning and rigour of the case study semi-structured interviews make a valid contribution to documenting real-world design activity in the emerging field of VR design. Although further work is required to broaden the examples used for case studies to include other companies and contexts, the use of the interview questions and structure remains relevant and applicable to similar communication-focused VR research projects. Secondly, the quality of the literature review, both in terms of breadth and depth, represents a significant piece of work in its own right, making links between HCI, communication theory and psychology from a design perspective.

One valuable aspect of the research was the philosophical and practical approach of fostering strong links to industry. Industrial involvement was critical to the thesis and involved significant organising during the early stages of the project, for example taking more than a year to establish the terms of intellectual property and contracts (see Appendix 1). The university and industry collaboration was fundamental to the success of this work, and lessons should be learnt in enabling better policies in future to speed up the process, rather than developing procedures on a case-by-case basis. From an intellectual and philosophical perspective, the support of BT, the Centre for Design Research (CFDR) and Design Research Society (DRS) in enabling the organising of colloquia to develop the research themes has added significant expertise and insights to the project from experts in the field. A further evaluation stage for practitioners would have allowed the testing of the matrix in practice, however the time constraints of the PhD did not allow for this and it should be seen as a strong area for future investigation.

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381 Case Study Analysis – Concept 2010 Q50 'Did the interface demonstrate structure between entities or relationships between information?' Appendix 3, p.118.
382 Gibson, J. J. *The Ecological Approach to Visual Perception.* Lea, 1987, p.36.

Finally, the programme of research has benefited from running on a part-time basis in that the longitudinal study of the subject has eliminated some of the influences of an emerging technology and allowed for staged reflection on a fast-changing industry. Consequently the case studies may not in themselves represent the current state of the industry, but have been put into perspective through the length of the study.

The principle simplicity of Virtual Reality belies the complex philosophical, epistemological and ontological questions that are inherent in the subject. With this research area it is clear that 'as you scratch beneath the surface the ground becomes very soft indeed'. Therefore, the issues raised by the technology of Virtual Reality are significantly more profound than the medium itself. As Levy notes: "The development of cyberspace, the quintessential medium of communication and thought, is one of the principle aesthetic and political challenges of the coming century."[383]

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383 Levy, P. *Collective Intelligence: Mankind's Emerging World in Cyberspace.* Perseus Books Group, 2000, p.119.

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GLOSSARY

Keyword	Description
1-D	"One dimensional visual structures are typically used for timelines and text documents." Card, S.K., Mackinlay, J.D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.57.
2-D	"Two dimensional structures are typically used for chart and geographic data but have also been developed for document collections." Card, S.K., Mackinlay, J.D. & Schneiderman, B. *Readings in Information Visualisation, Using Vision to Think.* Morgan Kaufmann Publishers, 1999, p.58.
3-D	Three dimensional refers to the visual display that exhibits breadth, height, and thickness or depth (standard 2D computer images and television displays create a flat image with only height and breadth). Pimentel, K., & Teixeira, K. *Virtual Reality. Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.407.
Action at a Distance (AAAD)	In Virtual Reality, the ability to perform operations that are beyond the physical reach of the participant. Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.431.
Affordances	"Directly perceivable, potential uses of objects (a ladder, for example 'affords' climbing) and are closely linked to ecological optics." Gross, R. *Psychology: The Science of Mind and Behaviour,* 4th ed., Hodder & Stoughton, 2001, p.222.
Anchorage	The function of words used as captions for photographs. Barthes, R. 1964. Also known as Denomination when the caption is a name of the sign represented. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.110.
Anomalous Categories	According to Levis-Strauss, categories which partake in the characteristics of both the binarily opposed ones. Anomalous categories have too much meaning, they are conceptually too powerful. Their excess of meaning which is drawn from both categories and their ability to challenge the basic sense-making structures of a culture means they have to be controlled – typically by being designated ' the sacred' or 'the taboo' e.g. Twilight (fits between day and night). Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.118.
Artificial Reality	Term coined by Myron Krueger in 1977 to describe his

research. "An artificial reality perceives a participants action in terms of the body's relationship to a graphic world and generates responses that maintain the illusion that his or her actions are taking place within that world." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.*
Morgan Kaufmann Publishers, 2003, p.16.

Arbitrary Signs According to Sassure, there is no necessary relationship between signifier and signified: the relationship is determined by convention, rule or agreement among the users. An arbitrary sign is unmotivated. Corresponds to Peirce's Symbol. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.46.

Augmented Reality Augmented Reality systems combine virtual representations with perception of the real world e.g. The use of transparent glasses on which data can be projected. "a type of virtual reality in which synthetic stimuli are registered with and superimposed on real world objects; often used to make information otherwise imperceptible to human senses perceptible." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.18.

Avatar "A virtual object used to represent a participant or physical object in a virtual world; the (typically visual) representation may take any form." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.13

Binary Oppositions "A binary opposition is a system of two related categories that, in its purest form, comprises the universe. In the perfect binary opposition everything is either in category A or category B, and by imposing such categories upon the world we are starting to make sense of it." For example, night and day. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.116.

Channel "The physical means by which a signal is transmitted i.e. light waves, sound waves, radio waves, telephone cables, the nervous system and the like" Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.18.

Code A system of meaning common to the members of a culture or subculture. It consists of both signs (i.e. physical signs which stand for something) and of rules or conventions that determine how and in what context these signs are used and how they can be combined to form more complex messages. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.19-20.

Primary Code – Verbal language

Secondary Code – Make an already encoded message transmittable along a particular channel for example; morse, handwriting, printing.

Connotation Connotation "describes the interaction that occurs when the sign meets the feelings or emotions of the users and the values of their culture."

"Connotation is the term Barthes uses to describe one of three ways in which signs work in the second order of signification" Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.86.

Cyberspace A term coined by William Gibson to describe a shared virtual universe operating within a collective computer network. "A location that exists only in the minds of the participants, often as a result of technology that enables geographically distant people to interactively communicate." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.17.

Denotation "Refers to the common-sense, obvious meaning of a sign." Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.86.

Denouement "Denouement is the wrapping up of a story such that all the story's loose ends are bound up." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.431.

Emoticon Icons which represent using an emotional reference. Rivera, K., Cooke, N. J., & Bauhs, J.A., The Effects of Emotional Icons on Remote Communication. New Mexico State University, Department of Psychology; *CHI 96 Conference Companion.* CHI 1996, p.99.

Enactive skills Knowing in space, manipulating objects. Bruner, J. S. *Toward a Theory of Instruction*, Belknap Press, 1974, p.18.

Feedback *In communication:* The transmission of the receiver's reaction back to the sender. Feedback helps the communicator adjust his message to the needs and responses of the receiver. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.21.
In computing: Sensory feedback and feedback loop.

Fishtank Virtual Reality (Monitor based VR) "The simplest form of VR visual display utilizes a standard monitor and is called monitor based VR, or more often, Fishtank VR." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.140.

Kinesthetic "Kinaesthetic cues are the combination of nerve inputs sensing the angles of the joint, muscle length, and tension, plus resistance to muscle effort (force). Kinesthetic cues are used by the brain to determine information about the world. Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.181.

Genre A way to categorise style: science fiction or mystery, opera or symphony, abstract or representational are all genres of particular media." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.64.

Haptic Our sense of touch and proprioception. Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.177.

Hypertext link Originally proposed as a concept by Vannevar Bush in 1945, this currently refers to a "network of nodes (also called articles, documents, files, cards, pages, etc.) that are connected by links." Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.404.

Icon *In semiotics*: According to Peirce and Saussure an icon sign resembles its object in some way: it looks or sounds like it i.e. a photograph. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.46.

A topological similarity between a signifier and its denotata. Three subclasses of icon include: images, diagrams and metaphors. Sebeok, T. A. *An Introduction to Semiotics.* Pinter Publishers, 1994, p.28.

In psychology: Iconic skills include visually recognising, comparing and contrasting. Bruner, J. S. *Toward a Theory of Instruction*, Belknap Press, 1974, p.18.

In computing: Commonly considered to be a metaphoric graphic symbol, like a folder or trash can, that represents a file or program by depicting an item in the real world. Shneiderman, B. *Designing the User Interface. Strategies for Effective Human-Computer-Interaction.* 2nd ed., Addison-Wesley Publishing Company, 1993, p.208.

Immersion "Sensation of being in an environment; can be a purely mental state (mental immersion) or can be accomplished through physical means (physical immersion)." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.9.

Index An index has a direct link between a sign and its object: the two are actually connected i.e. smoke is the index of a fire. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.46. Its signifier is contiguous with its signified. Sebeok, T. A. *An Introduction to Semiotics.* Pinter Publishers, 1994, p.31.

Interpretant "'The proper significate effect': that is, it is a mental concept produced both by the sign and the user's experience of the object." Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.42. Also related to 'sign' and 'object'.

Lexicon Vocabulary of language – lexical adj. relating to the vocabulary of a language – lexicographer.

Mechanical Media Radio, television, telexes, telephones. They transmit both presentational and representational media. Mechanical media use channels created by engineering. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.18.

Medium (Media) The technical or physical means of converting the message into a signal capable of being transmitted along a channel. Media can be presentational, representational or mechanical. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.18.

Mental model A human's set of beliefs about how the system operates; the user's mental model will inevitably differ in varying degrees from the designer's mental model.

Metadata Data about data, e.g. information or code to describe the properties of another object (colour green, font 10 etc.).

Metaphor Metaphors express the unfamiliar in terms of the familiar in that it acts as a 'vehicle' for the familiar and 'tenor' for the unfamiliar. Metaphor exploits simultaneous similarity and difference by working within the same paradigm (they are units with distinctive features in a paradigm). A good example in computing is the widely used 'desktop' metaphor. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.92. It can be broken down into two subclasses: metaphor ("is a") and simile ("is like").

Metonymy Metonymy makes part stand for the whole, associating meanings within the same plane of reality. The representation of reality is inevitably a metonym, we choose part of 'reality' to stand for the whole. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.95. It can be broken down into two subclasses, metonym (associates) and synecdoche (to make a part stand for the whole).

Mimetic / Mimesis An interface that 'mirrors' real-world artefacts and is therefore heavily iconic.

Motivation Describes the extent to which the signified determines the signifier. A highly motivated sign is a very iconic one; a photograph is more highly motivated than a road sign. An arbitrary sign is unmotivated. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.52.

Narrative ***Undirected Narrative*** – "A world provided for the participant to explore, with no pre-planned or pre-described story" Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.63.

Directed Narrative – "Directed narrative is the type typically provided by plot based works, orientated toward one (or a number of) predetermined goal(s) or denouement(s)." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.61.
Other types of Narrative include flexible narrative and plot-based narrative.

Paradigm In semiotics, according to Saussure, a paradigm is a set of signs from which the one to be used is chosen. All units in a paradigm must have something in common, each unit must also be clearly distinguishable from all the others in the paradigm. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.57.

Presence Short for sense of presence; being mentally immersed in a virtual reality. Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.9. Presence is also linked to immersion.

Participatory Design The central premise of user-centred design or participatory design is that the best-designed products and services result from understanding the needs of the people who will use them. Black, A. *User-Centred Design.* Design Council Online Resource (www.designcouncil.org.uk/design). 2004.

Presentational Media The voice, the face, the body. They use 'natural' languages of spoken words, expression, gestures. They require the presence of the communicator, he or she is the medium. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.18.

Real time "In computer simulations, it means that the computer responds to inputs in a time frame that a human would perceive as instantaneous. Typically this means a response less than 50-100 milliseconds." Pimentel, K., & Teixeira, K. *Virtual*

Reality. Through the New Looking Glass. 2nd ed. McGraw-Hill Inc., 1995, p.414.

Representation "The production of meaning through language. To represent something is to describe or depict it, to call it up in the mind by description or portrayal or imagination... To represent also mean to symbolise, stand for, to be a specimen of." Hall, S. (ed.) *Representation: Cultural Representations and Signifying Practices.* Sage Publications Ltd., 1997, p.16.

Representational Media Books, paintings, photographs, architecture. There are numerous media that use cultural and aesthetic conventions to create a 'text'. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.18.

Semiocosm The symbolic world, that of meanings i.e. the world of culture in the broad sense, the religious world in the most secular sense of the term. Findeli, A. Ethics, Aesthetics, and Design. *Design Issues,* 10 (2), Summer 1994, p.55.

Semiotics The general (if tentative) science of sign, systems of signification, means by which human beings, individually or in groups communicate or attempt to communicate by signal: gestures, advertisements, language itself, food, objects, clothes, music etc.
Bullock, A., Stallybrass, O. & Trombley, S. (eds.) *The Fontana Dictionary of Modern Thought.* 2nd ed. Fontana Press, 1988.

Signs "A sign is something physical, perceivable by our senses; it refers to something other than itself; and it depends upon a recognition by its users that it *is* a sign." Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.41.

Signification "The relationship between the signifier and signified within the sign, and of the sign with its referent in external reality" Further to this Barthes describes two levels of signification; Connotation and Denotation.
Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.85.

Signified According to Saussure, the mental concept to which the signifier refers. This mental concept is broadly common to all members of the same culture who share the same language. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.44.

Signifier According to Saussure, a sign's image as we perceive it, e.g. marks on paper.
Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.44.

Sonification "The presentation of information in an abstract sound form.

Every sound falls somewhere on the realism continuum. There are general ambient sounds, sounds that mark an event, sounds that continually provide information about the state of something, and sounds that augment or substitute for perceptions made by other senses." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.*
Morgan Kaufmann Publishers, 2003, p.227.

Superscape Virtual Reality software for PC computers. The software also includes Viscape, Virtual Reality software for the internet.

Suspension of disbelief Laurel notes similarities between direct manipulation and Samuel Coleridge's concept of the "willing suspension of belief."

Symbol (symbolic) *In Semiotics:* According to Peirce, there is no connection or resemblance between sign and object: a symbol communicates only because people agree that it shall stand for what it does e.g. words. Peirce's symbol corresponds to Saussure's Arbitrary Sign. Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.46.

A sign without either similarity or contiguity, but only with a conventional link between signifier and its denotata, and with an intentional class for its designatum.
Sebeok, T. A. *An Introduction to Semiotics.* Pinter Publishers, 1994, p.33.

In psychology: Symbolic skills refer to an ability to understand long sequences of abstract reasoning. Bruner, J. S. *Toward a Theory of Instruction*, Belknap Press, 1974, p.18.

Syntagm A syntagm is the message into which chosen signs are combined. A road sign is a syntagm – a combination of the chosen shape with the chosen symbol. A sentence is a syntagm. Syntagm require rules or conventions by which the combination is made.
Fiske, J. *Introduction to Communication Studies.* 2nd ed., Routledge, 1995, p.58.

Taxonomy The department of natural history treating of the principles of classification.

The "Ultimate interface" A natural invisible interface. "An interface so natural that users feel as if they are interacting directly with some virtual world, barely noticing the existence of the intermediating interface."
Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.98.

Verisimilitude "The quality of having the appearance of truth or depicting realism." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.212.

Virtual Reality A medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation (a virtual world). Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.13.

Virtual Reality Modelling Language (VRML) A scripting language used to define 3-D shapes for the use on the Web. Dinucci, D., Giudice, M. & Stiles, L. *Elements of Web Design.* Peachpit Press, 1997, p.200.

Virtual World "1. An imaginary space often manifested through a medium. 2. A description of a collection of objects in a space and the rules and relationships governing those objects." Sherman, W. & Craig, A. *Understanding Virtual Reality, Interface Application and Design.* Morgan Kaufmann Publishers, 2003, p.7.

Visualisation "Formation of an image that can't be seen. The ability to graphically represent abstract data on a computer that would normally appear as text and numbers." Pimentel, K., & Teixeira, K. *Virtual Reality. Through the New Looking Glass.* 2nd ed. McGraw-Hill Inc., 1995, p.417.

Northumbria University
School of Design
(In Collaboration with British Telecom).

"AN INVESTIGATION INTO COMMUNICATION STUDIES TO IMPROVE THE DESIGNER'S UNDERSTANDING OF THE VIRTUES AND CONSTRAINTS OF THE THREE DIMENSIONAL GRAPHICAL USER INTERFACE."

Andrea Mae Cooper, B.A. (Hons).

APPENDICES

A thesis submitted in partial fulfilment
of the requirements of Northumbria University
for the degree of Doctor of Philosophy.

November 2004.

APPENDIX CONTENTS

APPENDIX 1: CHRONOLOGY OF THE PROJECT

Key review points are in **Bold** including peer review presentations, papers and conference presentations.

Preliminary Project Set up Literature Review and Documentation	June 1995	Proposal to Department Research Committee for 'funded' research project.
	Aug 1995	Preliminary proposal to BT for 'Case like' funding.
	Aug 1995	Visit to BT to review proposal.
	21 Sept 1995	Attend 4D Dynamics interdisciplinary conference on *design and research methodologies for dynamic form*, Leicester.
	Nov 1995	Attend Computer Graphics Expo 95 Conference on Virtual Reality and Multimedia.
	Nov 1995	Initial research degree registration.
	Mar 1996	Visit BT to discuss potential case studies.
	Mar 1996	Attend 'Networking Design' Conference, Northumbria University.
	Dec1995 - Apr 1996	A substantive literature review leading to a critical bibliography.
	Mar 1996	Production of the project web site.
	Apr 1996	Second proposal to BT including timescales and deliverables with application for funding.
	May 1996	Attend *'A Meeting of Metaphors'*, Design Dialogues 2, DRS Conference, UCL.
	May 1996	Visit Creative Review Show attending talks on digital design.
	18 Jun 1996	Presentation to RDC of the RDC02 Document - Acceptance of RDCO2 - July 1996.
	Jul 1996	Preliminary discussion with Harold Thimbleby to discuss potential supervision arrangement.

Phase 1 Research Data Gathering	4 Jul 1996	Attend *'Designing the Internet – When digital design meets analogue thinking'*, Central St Martins.
	Sept 1996	Visit to BT for 2 weeks for information gathering and update on case studies.
	Oct 1996	**Visualising the future presentation to researchers and staff on project.**
	Oct 1996	Report to BT of the findings of the literature search.
	Nov 1996	Attend 'Serious Games' Exhibition, Newcastle with trial of Char Davies, Osmose VR.
	Sept 1996 - Dec 1996	Production of a propositional paper reflecting the findings of the critical bibliography.
	Dec 1996	Selection of case studies with BT & Octo Design.
	Jan 1995 - Dec 1996	A computer based journal of thoughts and developments.
	Jan 1997	**Submission of paper to Euromicro conference in Hungary - acceptance of the paper by peer review - April 1997.**
	19 March 1997	**Presentation at CDR *"Semiotics, Semantics and Dimensionality in HCI"* Northumbria University.**
	Jan - March 1997	Production of a Model of Communication showing key research issues.
	April 1997	Four propositional papers discussing the issues surrounding the 3D medium.
	May 1997	Production of a 15,000 word Transfer Document (RDC09).
	May 1997	Presentation to BT to review communication model and consider case studies.

Phase 2 Research and Data Gathering	**01 Sept 1997**	**Presentation of Research at *Computers in Art and Design Education (CADE) Post-graduate Forum*, Glasgow School of Art.**
	Sept - Oct 1997	Organisation of an expert forum at BT to discuss the issues surrounding the research.
	Nov 1997	Presentation to Semiotic Solutions.
	27 Nov 1997	**Expert Forum at BT '*Visualising the Future*'.**
	Dec 1997	**Presentation to Kodac Imagination Works – peer review.**
	25 Feb 1998	Attend "*Putting 3D on the Desktop*" ACM British Chapter, UCL, London.
	26 Feb 1998	Attend '*Designing Design Research 2*' Conference, School of Design and Manufacture, De Montfort University.
	Feb 1998	Production of 'Visualise' web pages.
	Feb 1998 - June 1998	Research period at BT: - Production of a case study implementation plan. - Development of a methodology report. - Case study interviews. - Information triangulation process. - Further literature reviews and conferences.
	April 1998	Production of paper for CHI USA.
	May 1998	Production of case study paper for IDATER.
	11 May 1998	Attend IEE Colloquium *"The 3D Interface for the Information Worker"* Savoy Place, London.
	June 1998	Review of findings from BT visit.
	11 Jun 1998	**Presentation of Research at *Computers in Art and Design Education (CADE) Post-graduate Forum*, Sheffield Hallam University.**
	02 Jul 1998	**Expert forum 2: Issues in Practice, '*Multiviewpoint Shaping the Human-Computer Interface*' DRS, Northumbria University.**

Review and Evaluation		20 May 1999	Visit to Domus, Milan for *'New Media Vision'* Conference and workshop, write-up of conference findings.
		Jun 1999	Review of literature to date.
		Jul 1999	Transcription and review of case study findings.
		Jun/Jul 1999	Production of a progress report for BT and supervisory team.
		Jun 1999	Visit to Harold Thimbleby with Progress Report.
		5 Jul1999	Attend *'Matrix for Research, International symposium on research in design and art practice'*, Central St Martins.
		31 Nov 2000	***"The Role of Three Dimensions and VR in Graphical User Interface Design"* Design in Business Week, 'Digital Media Design', Design Works, Gateshead, UK.**
		2000	***"The Use of Alias in Industrial Design and the Benefits of an Integrated Solids / Surfacing Methodology"*3rd International Symposium on Industrial Design, Hong Kong Productivity Council (HKPC), Hong Kong.**
		Nov 2000	**Presentation of Matrix of Communication to designers at Centre for Design Research.**
		Jan 2001	Development of Communication Model and Matrix.
		Jun 2001	**Paper for Digital Creativity *"Beyond the Icon"* Digital Creativity, Vol. 12, Number 2, 2001.**
		2002	**Paper *"The Use of Solids / Surface Modelling and Virtual Reality in Industrial Design"* Tools and Methods of Competitive Engineering, Wuhan Hubey, China.**
		8 Nov 2002	Attend RSA *'User Interface and Machine'* Conference, RSA London.
		14 Nov 2002	Attend *'Flow'* Doors of Perception Conference, Amsterdam.
		April 2003	Attend Doctoral Consortium CHI 2003 *'New Horizons'* Fort Lauderdale, Florida.
		28 Apr 2003	Attend European Academy of Design Conference, Barcelona.
		Apr 2004	Meeting with Daniel Ballin at BT to Review findings.

Write up	Feb 2004	Attend *'Transfigure'* Virtual Reality Exhibition, Melbourne.
	Nov 1999 - Aug 2004	Thesis write up - - Review literature review update, Jan 2004. - Second review of case study findings, Feb 2004. - Cross case analysis, Mar 2004. - Cross relation of findings to previous, Nov 1999.

APPENDIX 2: THE INTERVIEW QUESTIONS FOR THE PHASE TWO CASE STUDIES

Case Study interview questions asked of Call Waiting, Concept 2010 and 3D Retail.

General Description

Title

1) What is the project title?
2) Is there a history to this title?

Relation to the work of others

History

3) What is the relationship of this project to key historical projects:
    - 3a) Within BT (human factors)?
    - 3b) Within the field and known competitors?

Current

4) What is the relevance of this project in relation to other contemporary work:
    - 4a) Within BT (human factors)?
    - 4b) Within the field and known competitors?

Units & Sub-units

5) Is this project part of a larger project?
6) Is this project broken down into smaller projects?

Justification

7) What was the impetus behind the project:
    - 7a) Advancement of technological know-how?
    - 7b) Software development?
    - 7c) Dissatisfaction with existing solutions?
    - 7d) New product / service development?
    - 7e) Other?

Project Aims and Objectives

Before

8) What were the original aims and objectives of the project?

8a) When were these specified?

During

9) Did the objectives of the project change considerably over time?

9a) In what ways?

After

10) Were all the project objectives met?

10b) If not which were not met? and why?

Project Timing

11) When did the project start?

12) What stage is the project at within its original time-plan?

13) When did/will the project finish?

13a) did/does this represent a natural conclusion for the work?

13b) why?

People

14) Who are the key people involved in the project:

14a) Management?

14b) Strategic planning?

14c) Design?

14d) Implementation?

14e) Marketing?

14f) Delivery?

14g) Evaluation?

15) What are their backgrounds / what is their expertise?

(animation, graphic design, software development, industrial design, three dimensional design, computing, psychology, human factors...)

15b) Do they all work for BT? If not, who do they work for?

Data Sources

16) In relation to this project, what information is: (where is this stored)

16a) on file (folders, project reviews)

16b) on the internet (html pages about the work)

16c) on video

16d) on computer (interfaces, demos)

16e) physical imagery (story-boards, renderings)

16f) external review (published at HCI, newspaper clippings, television broadcast, interviews, technology exhibitions)

THE DESIGN SOLUTION (Interface)

General

17) What is the purpose of the interface?

18) Was there a brief?

18a) If so what was it?

SOFTWARE AND HARDWARE

Building the Virtual World:

Software

19) What software tools were used to create the virtual world?

19a) What is the release number for this software?

19b) Does this express the state of the art use of this software?

19c) Has this software changed considerably over time?

91d) Is it expected to change considerably in the near future?

20) What was the justification of using this software for the project?

21) Did the software represent an ideal choice?

22) Do you think that the software constrained creativity or facilitated the development of concepts? Please give an example.

23) Would it have been possible to create the virtual world using different software?

23a) What software?

23b) If so, would this have changed the design?

Delivering the Virtual World: (hardware and software)

Software

24) If different, what software will be used to deliver the product/service?

  24a) What is the release number for this software?

  24b) Does this express the state of the art use of this software?

  24c) Has this software changed considerably over time?

  24d) Is it expected to change considerably in the near future?

25) When was the means of delivery identified, at the start, during, end?

26) What was the justification of using this software to deliver the project?

27) In terms of delivery, did this software represent an ideal choice?

28) Do you think that the software constrained creativity or facilitated the development of concepts? Please give an example.

  29) Would it have been possible to deliver the virtual world using different software?

  29a) What software?

  29b) If so, would this have changed the design?

Hardware

30) What hardware will be used to deliver the product/service?

31) What is the optimum/minimum hardware standards for running the virtual world?

32) How did this affect the design?

33) Do you think that the platform for delivering the virtual world constrained creativity or facilitated the development of concepts? Please give an example.

Interface Descriptive Content

Interface Identification Overview

34) How many different discrete visualisations have been created for this project?

35) Which design represents the most advanced solution in terms of:

  35a) Usability?

  35b) Challenging conventions?

  35c) Commercial viability?

  35d) other criteria?

Specific Interface Identification

36) Does this interface have a title or name to characterise it?

37) Describe the key features of the interface?

38) Is the existing visualisation an example of on-going design or a finished concept?

Use of different Media / modes of representation

39) Describe the different types of representation used in the interface, are there:

- 39a) Two dimensional images?
- 39b) Textual information?
- 39c) Numerical information?
- 39d) The impression of three dimensionality? how would you characterise the three dimensional?

40) Does the 3d exist within a 2d metaphor or the 2d exist within a 3d metaphor, which would you say is the main mode of representation?

Functional content/ command/ control

41) Can users change information which is displayed to them, what level of change can they exert? high - low / none

42) How interactive can the interface be considered? high - low / none

Navigational / Interactive content

43) Is the interface immersive, screen based or both?

- 43a) Why was this chosen?
- 43b) Has it always been like this?

44) How can a user can navigate the space: i.e.

- 44a) Free movement, 2axis, 3axis?
- 44b) Multiple vantage points?
- 44c) Fixed paths?

45) Describe the 'action concept' metaphors within the interface: i.e.

- 45a) Move: (purposeful traversal) navigate, fly, drive, click and fly to?
- 45b) Browse: (low goal orientated review of options): Rapid replacement, scanning text
- 45c) lines, window shopping, thumbing through books?
- 45d) Scan: (very rapid browsing) fast review of scrollable items, fast review of buildings, objects, people?

45e) Locate: point, touch, circle items?

45f) Create: add (new), copy?

45g) Delete: throw away, destroy, lose, recycle, shred (permanent or temporary deletion)?

45h) Evaluate: point, touch, circle items?

46) What forms of input device can the user employ:

46a) Keyboard (typing/numerical input)?

46b) space mouse?

46c) normal mouse (in conjunction with browser navigation window)?

46d) any other?

47) How has this affected the design?

Navigational Architecture

48) How might the mode of interacting with the information be considered:

48a) hierarchical?

48b) networked?

48c) linear (fixed path)?

48d) hypertext / hyperlinks?

48e) could the user go back in time? (like the undo feature or movie player)

48f) Any others you can think of (describe)?

49) What was the reasoning behind the modes of navigation?

50) Did the interface demonstrate structure or relationships between entities or information?

50a) If so, how did the 3d differ from the 2d for conveying this?

51) Kineasthetics - How did the user relate to the 'known' aspects to the totality of the interface (i.e. how did users understand where they were, where the edges were, where they had been etc).

Animated content

52) Describe the animated aspects within the interface: i.e.

  52a) changed scale?

  52b) human characteristics?

  52c) emotion?

  52d) mechanical properties?

  52e) other features, describe?

53) What was the reasoning behind the form of the animation?

54) How would you prioritise the purpose of the animation in terms of:

  54a) action

  54b) intention

  54c) feedback

  54d) instruction

  54e) realism

  54f) other (specify)

55) What real world characteristics were employed? (i.e. speed of movement, bouncing, object collision, scale...others)

56) Did the animation break real world conventions? (i.e. teleporting, fly-through, impossible movements, lack of gravity...others)

Presence

57) How is the presence of the user demonstrated?

  57b) How important was this aspect of the interface?

58) Did the representation of users (avatars) have real world characteristics? (i.e. speed of movement, human features, physical motor constraints)

59) Did the representation of users (avatars) break real world conventions? (i.e. flying, changing body size (child to adult viewpoints), see oneself, multiple existence of self)

60) Can users leave tokens/objects in the space?

61) Can users pick up tokens/objects from the space?

62) Is the interface a Multi-User Domain (MUD)?

63) How do other people relate to the user in the space (i.e. text windows, visual gesture, speech..)

Visual Content

Overall

64) How would you describe the visual appearance of the interface?

65) Was a generic style intended in the visual appearance of the space?

66) What were the key features of the visual style?

67) What was the reasoning behind this choice? (library of objects, limited user understanding, conventions...)

Process

68) Was it always clear what kind of visual representations should be used? discuss..

69) How was the decision arrived at?

70) Were alternatives considered?

71) Why were these not employed?

Visual Use of Time and Space

Time

72) Was time visually represented in the interface?

73) How was the time conveyed:

  73a) Iconically (realistically):

    73ai) naturally (age, deterioration, lighting)

    73aii) mechanically (clock, digital watch)

  73b) Did the space have real world time characteristics? (i.e. night and day etc.), give examples:

74) Symbolically: using Logic or conventions? (as amounts, abstract movements)

75) How would you prioritise the purpose of the time metaphor in terms of:

  74a) action

  74b) intention

  74c) feedback

  74d) instruction

  74e) realism?

  74f) other (specify)

77) What was the reasoning behind using a time metaphor? (creation of belief, technological possibility, organise concepts, other...)

Space

77) How was the physical space represented visually in the interface:

- 77a) Iconically (realistically) –
  - 76ai) naturally (perspective, distancing, focus)
  - 76aii) mechanically (objects)?
- 77b) Did the space have real world visual characteristics? (i.e. distancing, focus, size), give examples: Did this cause any design issues? How were these resolved?

78) Symbolically: using Logic or conventions? (road signs, co-ordinate geometry)

- 78a) Did the space break real world visual conventions? (i.e. impossible shapes, sizes) give examples:

79) Did this cause any design issues? How were these resolved?

Referents

81) Where have the visual cues been derived from:

- 81a) Real world objects - natural, mechanical, digital?
- 81b) Symbolic meanings using convention?

82) Were some aspects easier to represent three dimensionally than others?
Give examples - represented easily:
represented with difficulty:

83) How were these issues overcome
(use of different form of representation, change to 3d representation).

84) In what ways does the interface behave similarly to its referent? (has textures, gravity)

85) In what ways does the interface behave differently from its referent? (changes colour, changes form)

Realism, symbolism (icon, index, symbol)

86) How could the interface be characterised using iconic, indexical and symbolic representation?

87) Is the interface mimetic?

88) What is the motivation of the signs? highly motivated/ motivated /not motivated

89) Where did the codes for the symbolic aspects come from? were they deliberate?

Metaphors

90) Were visual metaphors used in the interface? if so were these metaphoric or simile
91) Were the interpretants paradigmatic?
92) What was the purpose (message) of the metaphor?
93) Was an explicit choice made to use this metaphor?

Metonyms

94) Were visual metonyms used in the interface? were these metonymic or synecdoche?
95) Were the interpretants syntagmatic?
96) What was the purpose (message) of the metonym?
97) Was an explicit choice made to use this metonym?

Mental models

98) What were the main codes which conveyed the information (3d/2d/vr/desktop)?
99) What mental models were employed to link the visual information on screen? How could these be described?
100) Was the interface also intended to function as a mental model for the user to consider their future actions? If so in what way? Was it successful?

Conventions

101) Is conventional wisdom being employed? (computer interface conventions / social conventions)
102) If so what kinds of conventions were considered to be used?

Floating Signifieds

103) Do there appear to be floating signifieds? Are there ambiguities in the interface?
104) Is text used to anchor meaning? why?
105) Is denomination used to describe meaning? (are objects named)

Audio Content

Overall

106) Was a generic style intended in the audio interface for virtual world?

107) How could this be described?

108) Was it clear what kind of audio cues should be used?

109) How was the decision arrived at?

110) Were alternatives considered?

111) Why were these not employed?

112) Where have the audio cues been derived from? reality or convention?

113) Does the interface behave similarly or differently from its metaphor?

Audio Use of Time and Space

Time

114) Was time audibly represented in the interface? what was the purpose of this? (creation of belief, technological possibility, organise concepts, other...)

115) How was the time conveyed?

    115a) Iconically: naturally, mechanically (sound of clocks, bells)

    115b) Symbolically using logic or conventions? (beeps as with computer conventions)

116) What value did the audio time metaphor provide: action, intention, feedback, instruction, realism, redundancy? other specify

117) What was the reasoning behind the form of the time metaphor?

Space

118) Was the sound three dimensional? stereo?

119) How was space audibly represented in the interface?

    119a) Iconically : naturally (distancing, material sounds, animal sounds), mechanically (sound of objects)

    119b) Symbolically using logic or conventions? (doplar)

USERS

General

120) Who were the intended audience?

121) What was the previous knowledge of the intended audience, could this be specified:

    121a) directly, indirectly or by customer profile?

122) Were the intended audience expected to understand particular conventions:

    122a) Computer, designerly training i.e. dtp/3d, office environments, home environment.

123) Were user mental models employed?

    123a) What user mental models were employed?

124) Were the audience perceived to have similar cultural values and codes to the designers?

User Trials

125) What user trials were undertaken?

126) At what stage(s) were these trials undertaken?

127) Did the user trials suggest that the users reacted as the designer had expected?

128) What were the criteria for the user trials?

129) How did users rate in relation to these criteria?

130) What did the user trial reveal?

131) Did this change the design? If so how?

Pragmatics (Marcus 1992)

132) How did users comment on the usability of the 2d and 3d aspects of the design in terms of:

    132a) Legibility (speed of recognition)? [immediacy]

    132b) Utility (ease of use)?

    132c) Identifiability (intuitiveness)?

    132d) Memorability?

    132e) Pleasure of use?

Findings

133) What do you perceive to be the main successes of the project?

134) What do you perceive to be the main shortcomings of the project?

135) Were any guidelines discovered through the project?

136) What were the advantages of using 3D?

137) Do you think these were these specifically related to this project or more general findings?

138) What were the disadvantages of using 3D?

139) Do you think these were these specifically related to this project or more general findings?

140) Were any guidelines promoted or documented through the project?

141) Were any distinctions made about the virtues of 3d in the project documentation?

142) Were any distinctions made about the constraints of 3d in the project documentation?

Method Shortcomings

143) Were there any shortcomings in the way the project was carried out?

144) Were there any advantages to the way the project was carried out?

Recommendations

145) What recommendations were derived from this project?

146) Were any patents created as an outcome of the project?

APPENDIX 3: RAW DATA FOR THE SEMI-STRUCTURED INTERVIEWS (TRANSCRIPTS)

The Raw Data from the semi-structured interviews undertaken at BT Labs between Kim Fisher (KF) and Andrea Cooper (AC).

1.0 Call Waiting Case Study Transcript

AC: If we start with the background to the project and then what I will do is ask a few questions relating to that and we'll take it really casually so its not massively structured but these are the guides about what I will ask. So the first thing I have here is, if you can cast your mind back to the history of the Call Waiting case study, the first thing is, How it related to other projects historically before Call Waiting: so if there were projects that fed into it and what they might be and what relationship they might have?

KF: Call Waiting came from, we started looking at Virtual Worlds and data navigation, so we started with Emotional Icons, we went from a, we started with Emotional Icons as an idea we visualised it using Virtual Reality (VR) and then we went from that, to data navigation and we moved into the idea that you didn't need loads of icons bouncing around, the biggest problem was finding your way around information, and it was at that point that the particular project that was sponsoring it stopped and there was no funding to take it any further. We were then asked to look at service creation tool which was using the VR that we had done before the data navigation to visualise a service creation tool and that was a really, really complicated system, so rather than eat it all in one go, what we did was we looked at the end result, the service, and we then looked at all the various, I think at that time there were five or six services, star services they were called, because of the star on your phone that would invoke them, and one of them was Call Waiting, and, sat down and modelled Call Waiting. Now the essence of this was very different, we weren't modelling a telephone that had actual buttons on it, we were modelling a service that existed inside the network and therefore we didn't have any precedents to work on, on how to build the model, there also was a problem that all the models of services had been built from the one point to another point was 'a call' and we came up, they couldn't keep drawing lines and lines and lines on a screen we had to come up with a concept for a call that was different than a connection between a and b and that's where we came up with the concept for Call Waiting of an object which was a call, and once we did that we were able to generate the model of Call Waiting as load of blocks and things bouncing up and down, and it got paid for, instead of by the original exploratory money, it got paid for by the service creation tool project. So instead of being corporately sponsored as research it was now part of a development project.

AC: So, was there other work that was going on within BT that related to it service creation?

KF: A fantastic amount, I mean the actual specification for this service creation tool is, it was like a telephone directory, you know, *that* much information; and that was partly the reason why we didn't try and build a new tool to do that job, what we did was we looked at modelling the end result and from that in Call Waiting we ended up with particular pieces in the model that directly related back to what you could program in the service itself, so we worked from that end not from that end.

AC: I suppose that is within BT isn't it. That's the relationship with project as and with bigger aspects within BT, but were you aware at that time of any work going on outside of the company in relation to that whole thing?

KF: Call Waiting? No, in fact on all of the work I have done on Emotional Icons and Data Visualisation, I have purposefully not looked at other peoples' work. Because, my previous colleagues who had worked on Data Visualisation *had* looked at other peoples work and all they were doing was migrating from where the other people had finished. And I believed, and so did our bosses, that we got something novel, and instead of trying to specify the thing to death and then build it, what we were doing was playing with the pieces and then seeing what we had generated whether that could be applicable, so we were doing it the other way around on purpose, it was a different approach.
[Shall we test the video]

AC: The next point that I have here is in relation to whether it was a smaller part of a larger investigation or a larger part of a smaller investigation, but I think we have already answered that.

KF: It's a small part of a very large project, it wasn't an investigation. We were looking at ways of improving service creation, reducing service creation time and they were applying what I was doing to that problem. To see whether we could prove whether we could do anything or not, and we did.

AC: If you were to characterise this as a title would that be Call Waiting?

KF: Yes… no, it would be service creation tool improvements.

AC: Is that how it was known at that time?

KF: It was known by a number, because it was such a large project they had loads of different, 9146 or something and everyone know what 9146 was because it had such a large budget. And Call Waiting was just a tiny, I think 40ks worth of work to it, no 17/18K worth of work, and I was given it at the end of the year to come up with a demo that we could show at a final presentation of the project, that was the work.

AC: The next part I have here is to do with the justification behind starting it and the first part of that is really what the impetus was behind doing the project was and I have a number of different descriptions here if you want to describe it first though?

KF: Why was Call Waiting done? First of all we had come up with loads of ideas and we had never had to apply them to a hard problem. This Call Waiting was a hard problem, they had got a visualisation tool for creating services and it was massively complicated and it needed a lot of learning to be able to use it, and they thought that what we were doing would be able to make it simple.

AC: The project that its from, the Emotional Icons project, that is the next stage up. What was the impetus behind doing that? Was it more of an exploration?

KF: That was in the early days of systems research, that was set up to be, to come up with loads and loads of ideas and then float them, right, and then see, because Systems Research was set up with people who had been in Telecoms a long time, it wasn't a load of amateurs in there and we were therefore put into Systems Research to have the ideas that our normal jobs wouldn't let us explore, my normal job wouldn't let me explore it and I came up with the idea that data could have attitude and it could be a visual stuff and I explained that and that's how Emotional Icons got going and it was one of maybe twenty things I worked on as ideas and it was one that Dr. Rudge, who was head of research then seized on and said, spend more time on that. He went through; good, good, bad, bad, bad, good, bad do that sort of thing and it was one of the ones to get on with.

AC: And what were the aims behind that ...some of the descriptions I have here could be things like perhaps technological aspects and investigation of technology, or perhaps that it had something to do with software that was actually developing?

KF: No.

AC: Another thing I have here is dissatisfaction with existing solutions.

KF: It was dissatisfaction with existing solutions *totally* and what we did was we went out to find how technologies could be used to achieve that, so it wasn't a technology driving a solution it was, we didn't like what was happening at the moment and we wanted another way of doing it, we wanted many ways of doing it.

AC: In terms of, it was a research project and the goal and aim of the project was to..?

KF: To explore a possibility of 3D data visualisation.

AC: OK, one of the other things I have here is New Produce/Service development. Did that feature in the aims of it?

KF: The only place it was ever going to get used was in a new service or a new product so its ultimate intention would be to be applicable to our business.

AC: Were there any other background justifications behind it that perhaps haven't been covered here? By these descriptions that I have?

KF: None that I can think of.

AC: OK, the original aim of the project, was that something that was quite clear right before the start of the project?

KF: No.

AC: Or was that something which evolved in time?

KF: No, it evolved, we were asked to ...minds roam, we came up with, I came up with ten ideas in about three months with my colleagues, it wasn't on my own and then we had a sifting process and we followed them after that, individual ones that were sifted by a sort of group approval.

AC: Did those aims of the objective of the project, did that change considerably over time?

KF: Yes.

AC: Were there any key stages, you could identify?

KF: Once I was able to visualise my idea, so I could have lots of paper lots of sketch sheets, but the moment it started bouncing on the screen it was then immediately accessible by everybody, not just within my group, but anybody could watch it and anybody could watch it and understand it and in fact that was its greatest strength because it obviously worked because I didn't explain it to anybody. It immediately became self-selling. It then became a demo that was always shown and what was interesting, because it was so bland and so basic, we could apply it to any customer we were talking to. It was *core*, not an example of home shopping or anything it was just core data so you could apply it to anything.

AC: So it was a mental model it kind of worked with many different?

KF: That was Emotional Icons, Call Waiting came some time later, let's get them right, and Call Waiting was never really shown to the people who could have adopted it. It was shown to the people who sponsored the service creation tool and in fact, what we developed was a way of visualising services to the end customer not to the person who was building it.

AC: So was there a particular reason why it wasn't shown to the people who might be developing that kind of tool?

KF: Politics, it was too much for that end customer to swallow at that time I reckon, too big a leap of faith.

AC: These questions are kind of ...

KF: They will boil out where it came from.

AC: I suppose they are the dry side of it, but at the same time it will enable us to see that we are comparing like with like and it will be process and structure.

KF: Structure.

KF: The comment that was made was that Emotional Icons and Data Navigation was research, now do something real. And the real thing we did was Call Waiting and it was a lot more difficult to apply the ideas we had to a real service and we came up with the initial Call Waiting demo and that had lots of backward implications back into research and so we took it forward and then it prompted a lot more research.

AC: So the Call Waiting side of things, the context within which the application of the Emotional Icons research, is that just fortune that that particular project came along at that time?

KF: Yes, purely fortuitous. Basically they were the only people who had some money who actually had something that we could apply it to and it all happened at the end of a financial year when they needed deliverables and we needed money.

AC: But actually it proved to be quite a useful project?

KF: It got used out of proportion to the amount of time and effort spent on it. Yes.

AC: If I could just go back a bit further behind, from memory can you remember when the project first started?

KF: Four or five years ago.

AC: The Call Waiting part of that?

KF: Three to five years ago and it was all done at that time, bang, in quite a short period of time.

AC: And that project...where is that within its timescales?

KF: Now...its had its useful life. It's as an idea sitting there as a latent idea that we can apply anywhere, and it doesn't have an owner other than me, its dragged out every two or three months to be shown to somebody and nobody has as yet copied it.

AC: Within BT or?

KF: Outside BT, it's been shown outside a lot.

AC: Is there a reason why that may be do you think, or?

KF: No, I think it did what it was supposed to do, which was to prompt the idea that you can think of different ways of creating tools different ways of visualising things, and with the advent of the net and the advent of screen phones, I think that this will become a way, it will migrate to a way of showing services to customers, explaining things, but its day hasn't come yet.

AC: So do you think that the, has the project itself finished?

KF: yes it finished when the money ran out.

AC: But you don't see that really, or is that a natural conclusion, or is that?

KF: The ideas there, no, no. That was successfully did what the money was there to pay for it. Better than they expected. But the ideas still exists and a lot of the people I work with know it, so it's in the back of your mind when you are developing other things.

AC: So it's more of a ...partly, a stepping stone to a ...

KF: Yes a stepping stone, definitely, a long time ago.

AC: In terms of the people who were involved in it?

KF: There were really only three; myself, Amanda Oldroid, who did the next version which she did when she joined the company, the first job she did was to take my demo and make it much more customer facing. And then the third person was a guy called Brian Salt, who was the guy at Superscape, the software company, who helped me build it, because I didn't know how to drive the tool then.

AC: And the three of you were the only people really involved in it?

KF: Yes, I think, there's only two of us on the patent Brian and I.

AC: And, the Superscape chap Brian, He's not BT at all in any sense so he is totally external to it.

KF: And he built, I had the idea, I built a very crude model that didn't work and I went down to do a training course to learn how to build with the tool and as a training exercise he and I together built my model, and that's the same model that you see today, it hasn't changed.

AC: And is that the only involvement that he had, is in that training?

KF: Other than his enthusiasm and his instant understanding of what I was trying to do. If you haven't got somebody who understood the idea that we were trying to make models of things that didn't exist, rather than Virtual Reality, this is Virtual Unreality, if you know what I mean, because a call doesn't exist as an object.

AC: People have modelled it as, as you say between two lines as an idea but it's difficult to do.

KF: We couldn't do that, you run out. Ten lines off, ten lines and you've covered the screen you know, and nobody would gain any benefit from that.

AC: Here I have got a list of areas involved in it would you say that it had covered these areas or?

KF: The only people who really got involved in it were people who were researching user interfaces in our own area, people who were researching user interfaces in the service creation area which is different. And since then lots of people in the development of telephones and the services have seen it, but more passively, nobody was actively involved in it, because it was a very simple start.

AC: And, Amanda's background is?

KF: An animator, she came in here and it nearly killed her, because she had used an animator friendly package before and she came to change my demo to a different one, to a more professional one, and she not only had to join a new company but she had to learn an unfriendly package and then do something creative with it.

AC: And that package is?

KF: Superscape, as was, it was version 3 then or 2.5, I think maybe, it's now 5.5 some four of five years later or so, it's very difficult to know, your paper work will tell you when it started won't it.

AC: Yes, there are questions that we will come on to that relate to the software specifically. The only other thing I have in the background here, is in relation to places and sources at which the information was disseminated. The example I have here. I have a copy of the file and folders, which I know of in this case, was anything ever put on the Internet about it?

KF: No, the Internet didn't exist then really quite in the sense that it does now. It did, but it wasn't somewhere you would publish.

AC: And nothing has been published there after?

KF: Yes, yes, an article about Emotional Icons that included Call Waiting was published in a joint article written by myself and Martin Cooper and that was for a BTEJ article…

AC: BTEJ?

KF: Engineering Journal (BTEJ) or Technical Journal (BTTJ) article that's published externally. It's a sort of thing like the publications from Bell Labs, you know, its one of those type of publications. So it has been published. But it had to be patented before that.

KF: What we were doing using, What came out of it, out of Call Waiting, was the concept of a virtual reality object with code attached to it with attributes so you could use it like Lego bricks and build services, and as you built them in the virtual world they worked, but then you threw away the visualisation and you had written the code. So it was Virtual Reality object orientated programming came out of it. And that was what was patented.

AC: The other things that I have here on my list here there has nothing put on the internet since then about it?

KF: No, Well you can find it, but it is referenced from Peter Cochrane's site. The emotional icons will refer to Call Waiting and Peter Cochrane refers to emotional icons and he has used it I think in his book.

AC: So he has referred to it, but there isn't a specific site about it?

KF: No, no. It's a part of a part of a part of a project.

AC: Is there any video data around on this?

KF: I've got some video recordings of it on screen, here.

AC: And we have got the computer demos, is there two demos?

KF: Yes, there was one that Brian Salt and myself produced and then that was just Call Waiting. And what we then fed that back into the services project you know that it was delivered into. And we got some money the next year for Amanda to look at all six services using the model, grow the model, to include the other services, so it went from Call Waiting and then it was looking at call timer, and call divert using an expansion of the same model and three way calling. There were five or six star services. Built on the same pieces and built the other services, or tried to. And then it was at that time that that I think that project was stopped as well, but not because of us, but because of other things.

AC: Why was it stopped?

KF: I think that basically the funding was cut because it was an enormous project. And we also had other things to do, so we just left it part way and they just used the demo.

AC: It wasn't because it was an unviable idea.

KF: No, no. The other thing that was suggested that we go out and market it inside the business. And at that time we had been asked to do something far more marketable, so we got on with that rather than continue with the Call Waiting and the service creation side.

AC: And the other of the five star services, were demos made of those?

KF: No, the pieces were built but we had never made the final model, I can show you those. They would have just been building rather than being innovative and creative. We had got the pieces it was just like using the Lego to do something different. We had built the original pieces to be able to make all five of them or six star services. We had a problem with three way calling - It was extremely difficult idea to model. Because there is one characteristic of three way calling is that who ever initiates the three way calling sort of owns it, so if they cleared down it clears down everybody else.

AC: Was that difficult to represent?

KF: It was in the logic that we had already used up to that point because it didn't have any modelling of, who on the call, who was paying.

KF: Nobody owned the objects in the model that we had up to that point and it wasn't until, owned the call, because in a normal call either end can shut down but one is paying for it. But In a three way call the other two people can go in and out, but if the originator went out the other two would fall out.

AC: It was more of a hierarchy?

KF: It could be but the whole thing about a three way call is that when it is happening there is no a hierarchy. And we were talking about call hierarchy not charging hierarchy, we were always talking about connectivity not charging in all the models that we had done up to that point it had got no Lego piece for charging in it.

AC: Was there ever a desire for having to have that?

KF: The reason for doing Call Waiting was that people didn't use it. And the reason was they didn't have an understanding of what it could deliver and b how to use it.
The human factors approach was that they didn't have a mental model of what it was.
So we built a virtual reality mental model and that was the use for it and once they had a mental model then they found it much easier to operate it. So it was to do with people and use not people and charging.

AC: And there was no way of adding on that?

KF: Yes we could. But, we could crack all five but not the six without the charging thing. And the charging, to be honest, didn't add any value to the user interface we spent a lot of time trying to work it out and I'm sure we could do it now but it seemed insuperable then.

AC: Is there any story-boards or renderings any physical drawings.

KF: No, no it was never drawn. It was always built in the model. Amanda may have done some drawings but to be honest I think she modelled them.

AC: There were no three dimensional models of it done?

KF: It was a lot easier to do it on the screen than to do it as an object, because it wasn't an object.

AC: In terms of external review was anything published any HCI events?

KF: Its been shown, It has not been flogged to the HCI community at all it has been flogged straight to the end customer so it appears at BT high technology exhibitions to real paying customers, you have got to bear in mind that initially the work on it wasn't done on the human factors division it was done in systems research and then I migrated into human factors and that's when Amanda came in. And we weren't integrated into human factors as such because we were in a different room for another year after that. So it was probably done on the edge of human factors.

AC: Was it ever televised?

KF: Yes it has been on television Channel Four; well it's only used as a sort of two or three second bouncing icon. Things like 'London in the next millennium' was one programme, because they were looking at what would happen to the city when technology hit it. And this is the type of technology that would help city traders. I've got a copy, its one of the demos that gets shown and bits of it are just sort of used as filler.

AC: Did you do any interviews on it?

KF: Not on it specifically. I did present it to two or three particular groups of people for the service creation project. So there were two or three major project reviews, and I presented it along with all the other software and ideas so I was one of eight or ten exhibits.

AC: Any newspaper clippings?

KF: No, none on Call Waiting alone it was part of the whole idea of emotional icons data visualisation. It was never on its own.

PART TWO

AC: This is the second part of the semi-structured interview. The questions in this section relate to the actual specific interface part of the project rather than the context within which that is.

AC: So if we take the actual Call Waiting interface itself, what is the actual purpose of the interface, I suppose in its broadest sense in a general way?

KF: We were actually, the demonstrator we created as a model for service creation software writers to help them build services using pieces of the network as objects and sticking them together, network functionality, and sticking them together, and we found that there were three particular customers actually for a model. One was the people developing the service another one was for people who selling the services and another one for the customer who was using the service. And prior to this there has been one model of how it worked for the programmer another one of how you would sell it and the third one was the customer experience which was horrible.

KF: For the first time we had generated one model that could be used by all three, and therefore what the customer, the end user, didn't like could be directly translated directly to the model that the programmer was using and this was the essence behind its success. Was that all three the customer, the person selling it, and the person designing the service could use the same mental model in this case it was visualised as one model. That was the reason for the interface or what it was and therefore any of those three people could use it and get something out of it.

AC: They are very different audiences

KF: They are human beings so they are all the same. They just have different levels of knowledge of the service that's the answer I always gave, a bit bland.

AC: was it created with one particular group in mind?

KF: It was driven by the one in the middle people trying to sell or explain the service. Either to say is this what you have designed you Mr. systems designer or this is how you use it to the end user. It was actually designed for use by the people trying to explain or sell the service. Rather than the end customer or the software engineer that's who it was aimed at.

AC: and in that sense did it also meet with the people on either side of that?

KF: Yes, in fact it had very wide appeal, it even had an appeal to software designers but didn't work on service creation because they could see if they had a tool like that for their particular software problem they could use that approach, which I believe we could call the emotional icons approach.

AC: So the fact that it was a visual interface that suited all three

KF: It was the only type I knew how to do. If I knew how to do an audio interface it would probably be an audio interface.

AC: So the interfaces that the groups used to have, what were they?

KF: The services creation designer had a very, very complicated very technical version of boxes and lines it had intelligent boxes that knew you could connect that box to that one on a UNIX system. The person selling had nothing other than that they went on training courses of how to use the service and were given a load of bullet points.

KF: And the end user had a manual that the human factors spent a long time refining. But, it was like trying to make a silk purse out of a sow's ear. Because all the button codes were being set by switch manufacturers from software engineers they weren't being put together by human beings they were things left over, legacy systems that were now being forced through codes to do jobs for customers.

KF: So they had a very difficult job explaining this logically from the codes, you know, Star hash fifty three hash is not a logical way of interfacing with Call Waiting.

AC: Do you think that that mode of describing it suited any group more than others.

KF: Which the visual mode, the three D? The engineers, no, it was just legacy for them. They really didn't care it was just what was left.

AC: Is there a copy of the guidelines that were created

KF: Yes you could get those it comes with any star services manual it's probably in one of the books that you have.

KF: Because the very first work we did was we cut out little counters which were the keys, and we laid them out and tried to animate them to begin with. And it didn't work. And that's when we realised we were trying to animate a line between two numbers. And it just wasn't working.

AC: Still in general terms, was there ever a formal brief for it?

KF: Yes, there is a little document it came from a Don somebody or other, who is still here, and he is seriously clued up on service creation tools. That book he knew inside out, all the things you had to do to create a service, he knew it, in here, and so there was no point us reading it because this guy actually understood it. He wrote a very short A4 of what he wanted to get out the end he wasn't telling us how to do it. He wanted a demonstration that reflected Emotional Icons as applied to a service creation, that's all he wanted at the end of it.

KF: Ultimately, he wanted, when during the project, what it looked like we could create would be a set of pieces in VR that reflected the pieces of software functionality inside the telephone exchange and what we were going to get if we carried on working with it, was a set of pieces that any customer, like a telecoms manager in Waitrose, could on his PC, stick the pieces together and say that's what I want and send it back as a requirements document, back to BT that's what they wanted because if you sit down you only get an hour to talk to the telecoms manager but if we gave him a toolkit in VR he could stick all his services together and route them all together and build a model and test it, he would spend hours doing that, he would then save it on a disk and give it back to us and we would get a very, very much clearer requirement of what the service was, and that was the ultimate aim after we had started the project, we never got to that stage because I think it got axed, not so much axed as a technological or a BT shift, like we're not going to develop services we're going to do something else, and whoosh the whole team went over to do something else.

AC: If we have a look at the software and hardware side of it. We've mentioned already that the software to create Superscape. Was there a release number for that?

KF: An old version that ran inside DOS. I think it was 2.52 or 2.53.

AC: Did this represent the state-of-the-art for use of this software?

KF: Yes.

AC: Did this at that time or does it now?

KF: At that time it was the state-of-the-art it is still state-of-the-art but its on version 5.5, it runs inside Windows 95, it doesn't run any faster than it used to. Its just the processor speed has gone up and they have added all this rubbish to it.

AC: Between the early version that you had there, has that software changed considerably over time?

KF: O' fantastically, before you had to be a coder now a designer can use it, and that's why I worked with Brian Salt there was nobody in the business other than Paul Rea who knew how to drive it and Paul was using it to do something else so he hadn't got time to teach me.

AC: Are there any specific aspects of the software that make it easier to use as a designer now?

KF: It's basically following all of the Windows conventions now instead of being a stand alone DOS application that you had to learn.

KF: The biggest problem was it didn't seem to have a logical tree structure to the commands when I was originally using it now it has tree structured all the commands logically whereas before there was a logic but that was the logic of the designer not any other. The logic of the person who wrote the software.

AC: So it has become more universal?

KF: Vastly more so. A lot of the things you used to have to code have now become buttons to apply it to so whereas before you used to have to give something velocity or gravity now every object is created with gravity and now you just change it. Do you see what I mean? Everything had a palette of colours instead of defining a colour. All those sort of things have changed.

AC: Do you expect the software to change considerably in the future?

KF: O' yes.

AC: Are there any specific areas that you think might change?

KF: I think it will become universal in the sense that there are two standards at the moment or two that I use, one is VRML the other is the VRT format which is Superscape. VRT and with the advent of web browser plug-ins Superscape have developed the universal player and they have made their software save in both and load from both formats. So they have got rid of the standards problem.

AC: Would it have been possible to create the virtual world using different software at that time?

KF: Yes, there was something called world toolkit and we had a copy of it, that was much cheaper. To colour it and another piece of software to stick the images on and another one to stick the sound in, right, they were all separate pieces of software themselves and they didn't all talk to each other and Superscape was the first one that put them all together in one piece of kit, in a compatible, and they stored all the pieces together whereas before you would have your wav files here and your image files here and your model files there. Superscape stores it all in a VRT file.

AC: So was Superscape the ideal choice for that project?

KF: There were two other, it was for me because it was the only type of the three types, there was another one that Gary Dalton used at the same time, I wasn't working with him at that time, that was called photo VR which was an early precursor of a cross between QuickTime VR and Superscape.

AC: You mention photo VR, was VRML around at that time?

KF: Possibly, but only in a University, probably free, not really an alternative, not that I know of, there were an awful lot of modellers there were hundreds and hundreds of modellers and animators but there weren't any dedicated virtual reality, o yes there was there were there was Virtuality but theirs was a custom built suite of software which they used on their own headsets and they, they never released to us a toolkit that would allow you to build the worlds. They only sold us the kits we bought number one and number two. I didn't, they were bought here before I was involved in VR, Laurence Bicker bought them.

AC: Do you think the design of the solution would have been very different with different software?

KF: No, but the visual of rendering, maybe the ease of use, yes, but the thing about it is that VR software is a bit like a camera, if you cant take a picture it doesn't matter what the camera is. So we were going to get these ideas out. It was the ideas not the tool that was the problem.

AC: Was the software that would deliver the service / product interface different from that which made it?

KF: Yes, it would have been, what we were ultimately going to do with it was, we were going to stick it on a CD that you didn't see Superscape on it at all and it would have BT written through it and it would be used by a comms. manager and there was another so it would have been totally unbranded, it may have used their renderer or it may not, it would have been stand alone package.

There was another use for it, on black and white screen phones, LCD screen phones, we were going to replace all the star dot star with a little screen a dot matrix screen that had the service modelled and animate it from our drawings or our pictures back onto the screen phones. So you could touch a call and drag it, and we did storyboards for that but then lots of screen phones were coming in at that time and they were going to be big text and buttons all around them. ADSI phone, but its interesting to see that that did not take off and what's happened is that the BT magic phone which is a Windows phone and that's coming out.

AC: The actual software that delivered the service, was that chosen up front or was that just something which just?

KF: It would be the final delivery platform, it was independent we hadn't got aspirations to do that work, we had got aspirations to move to the next level of funding, we hadn't got aspirations, we had got aspirations but no plans to move it to a different platform. There was no problem in platform. Because what we were sorting out was the idea, not the execution, we hadn't got the idea right. We were using it as an ideas visualisation.

AC: In terms of the actual delivery software, did it affect the design as well?

KF: Yes.

AC: In what ways?

KF: limited palettes, limited ability of the person building the model, you know, there wasn't a piece of software then that was easy to use, this was the easiest to use. And things like - there was a model of a telephone its not a BT telephone but as it was easier to use one that already existed, we used it, it was in fact a Bell telephone model, our competitors, from Bell Labs, it was one of theirs not one of ours.

AC: If we move on to the hardware side of things what hardware requirements were there to deliver the service?

KF: To deliver what Call Waiting? As my demo? or the actual final service Call Waiting needs a complete national telephone exchange system to deliver the service Call Waiting but to deliver my demo you only need a PC, I think we were running it on a 16 mega hertz, DOS 386 or something.

AC: I think the question will need to relate to the actual service to the customer but in this sense we can use in terms of the demo.

KF: It would be run on a very basic PC it didn't need anything special, it would need a sound card which was difficult to find throughout the business so I used to probably lug the PC around because mine had a sound card they weren't common.

AC: What would be the optimum system hardware to run it?

KF: Anything, a Pentium, we were running it on 386s and 486s, and it just gets, the animation is such that if you move from a-b on a fast machine it does more cells in-between but the time from a-b is the same, whereas if you've got a slow machine, the time from a-b is the same but you just get one cell or no cells, it just goes bang bang. And so adding speed to it or memory just makes the animation smoother it doesn't add to the actual function.

AC: Did the choice of both software and hardware affect the design of it?

KF: Yes, it would have.

AC: In what way, did it constrain it or did it...

KF: We made the modelling very, very, very, basic so that the machine could do it in quicker frames.

AC: In what sense do you mean basic?

KF: Instead of showing the call as a sphere with lots of facets on it we would make the call a cube with six facets on it, instead of 160 or something, it didn't look so posh, it didn't look like a ball bouncing up and down it was a cube.

AC: The less facets the faster it would run?

KF: Yes, yes, yes, much faster.

AC: Were you limited in the amount of memory / facets you could do at that time? Yes, yes, we were down to less than a thousand facets if we wanted to render anything over about five or six frames a second.

AC: Do you think that the platform for delivering the VR constrained creativity or facilitated the development of concepts or perhaps both?

KF: I think the second one, it facilitated. Given an infinite piece of paper you don't know where to start you've got a load of constrains in there you can be highly creative in getting the most out of it.

AC: So did the software play a part in the design?

KF: O' yes, in the sense that it had functionality which we used to get our ideas across. Let me see if I can explain that. We can flash an arrow ever so easily whereas to get an arrow to move wasn't easy. So we flashed the arrow. Right.

AC: The next part is actually going on to using it, so that makes sense if we go on to do that.

AC: The first one that I have here is to do with just the interface itself as an identification, as an overview. How many discrete visualisations were actually created?

KF: Two.

AC: Which would you say represents the most advanced of those?

KF: The second not this one the one Amanda did.

AC: I have some terms here perhaps the most advanced in terms of

AC: Usability would be?

KF: Amanda.

AC: Challenging conventions?

KF: Mine.

AC: Commercial viability?

KF: Amanda's.

AC: Do you think that there are any other criteria which could isolate the two?

KF: As we made, what we found with it was, as we refined the model and the user interface to telephony it was less easy to apply it to other services or even use it as an example of how Emotional Icons could be applied to different jobs or whatever. As it gained a context it lost its ability for people to understand it.

AC: That's interesting, shall we zoom in.

KF: What this was, its going to be a, it's a demo that's driven by somebody showing somebody else, in this case so it's not a user driven demo it's a demonstrator driven demo.

AC: In the user groups that we were talking about before would that be perhaps a marketing type person?

KF: Yes, the person teaching someone else to use it as a sales tool or having the service person teaching the sales person this is how the service works.

AC: If you would like to just go through it as the demo?

KF: Explain what it is?

KF: Basically, we provided two areas on the screen the 3D world here which we used very little of the ability of the 3d ability of that the ability to fly around we don't use that a lot here. And the other side we put in function keys down the side and what we did here was

we had the idea of a telephone exchange functionality as the blue bit in the middle. And the calls came in and they could go out. Right, and we had a telephone to which the exchange could send the call. And then we put a big button in it that allowed us to turn calls on and off inside the world.
There is a keyboard on the telephone here and, but, what we found was that was too difficult to get at sometimes so we replicated the keyboard up here, and we also started putting in functions here that would show you what was going on in the system because there were lots of indicators that the service was creating all time you do a call like it would know; who it was from, who it was to, call duration, who was paying what the cost, all sorts of things. But we only left it as the length of time of the last call. We, one of the interesting things was as this was the very first model we didn't know where to put the code so we actually made some chips that live in the world to put the code into, because we were starting to design something that didn't exist.

Where as before you would put the code inside the object yes? First of all it had sound so you could send in a call and then we used convention here to lift the handset, there's a rendering error there. And we added a bit of emotion to the call itself so it started talking to you and you can see a flashing arrow to show that you have received a call and it is sitting in the tray.

KF: In Call Waiting you can store one in the exchange and listen to another and then you can switch between them. So in comes a call and you answer it and then what happens in Call Waiting is while you are on the phone another call comes in and what happens at the moment is on in your ear you get a bleep. We put a sound in relation to what it was trying to do in the model and then we go over to the logic that is associated in the telephone exchanges.

KF: And we made it just pulsate and it shrinks and it was going to turn bright red and get angry after a long time, but we never got it to that point. And then you press two and it moves the call that's come in to the other tray, yes, and that's what happens in the exchange so it puts one to one side and then it puts it in. And you are now listening to that call. To go back to the call before you have to put the one you had on hold which is 'r' and '2' again and it switches back and the call reactivates and it leaves that call and you have got two call stores, basically. That's what you do 'r2r2r2' and in fact some of the customers call it 'r2d2' rather than Call Waiting because that's what you've got to do.

And 'r' will in any service put the call on hold before you do something else, so that's a consistent function.

AC: Does 'r' stand for anything?

KF: Recall, it means sending a recall tone down to the line to the telephone.

KF: Then when you put the handset down the call clears away and the call that's on hold phones you, the exchange calls you back. So what you do as a customer, lift the handset and were stored. Well it was just held not stored and then you clear down and you killed the call and it resets again. And that was the whole of the Call Waiting idea there.

KF: Do you want to see Amanda's version?

AC: Yes

KF: So we have not really used the 3d ability world really, we used it as an animator really. These are all demos strung together.

AC: If we stick with the one at the moment we will go to Amanda's at the end.

KF: Ok, so you want to go back to Call Waiting.

KF: That's Call Waiting they are all tied together.

AC: Does this particular interface have a name that you can characterise it with or is it just yours and Amanda's?

KF: This one is mine Amanda's is a very different way of doing it. In fact she modelled the objects differently and what she did was, she, this one was totally dedicated to Call Waiting. Amanda's is a demonstration that is made out of Lego pieces that works similarly but also have the ability to be used as Lego pieces for the other services. This one didn't.

KF: There was one other concept in this which I always used to demonstrate it was I put it into toolkit mode and say that one of the things the customer could do was instead of two call stores they wanted three, you could pick a call store and then say that was an object, duplicate it stick on another one and you have now created a service right, with three call stores. You could then run the service, yes, now you have created one with three call stores and you could see that you have made programming errors, you see what I mean, so not only could you use the tool to visualise the service you could build services with it run them and see where the bugs were and if you actually go back to the original thing you will find that if you go up one, that is the group which is the Call Waiting and this object was never part of the whole of Call Waiting so it was never adopted, if that had been adopted, bonded to it as an idea, it would have worked with it. And it sort of shows how the structure. And also when you copied these objects along with it that's the code and that could contain the code from, that's needed to drive the telephone exchange.

AC: When the engineers were driving it before were they just doing it in command lines of text?

KF: No, they were doing 2 D objects and then they would, that wouldn't create copies of code though that would only give structure and It wasn't animated it was just purely a flow chart. It did have rules on you couldn't connect this to this, it wouldn't draw a line if you tried to because there wasn't a communication channel or something. Whereas this is completely different. And yet they understood it.

AC: Is this particular visualisation an on-going design or a finished concept?

KF: Finished.

AC: In the interface you have used different types of representation for example 2D, 3D image, numerical and textual data?

KF: Which one is on top of which?

AC: Would you say that all of those were used in this particular one?

KF: Yes, they were all mixed together, not very well. But once the idea that there was a 2D activation window and a 3D visualisation - That everybody understood. It was when you started to being able to activate in both the 2D and 3D, they started wondering.

AC: The three dimensional aspects, how would you characterise those in relation to the others how could you characterise the three dimensional?

KF: An extremely powerful way of visualising your ideas, they are interactive, they are so much easier to create than an animation. And they are much more flexible. Like you want an animation to lift the handset and you have a problem and you can't get out of the problem. Whereas with this you can change viewpoints and everything. The file is tiny its probably 300k and you can give it to people. Whereas a big animation to do all of this would be enormous.

AC: Was it clear when it was right to use text when it was right to use images when it was right to use words?

KF: It didn't really come into it. We weren't after using text at all. The use of sound was a shock really because it was so powerful. So text didn't really add anything other than, I mean you could take the 'c' off that button and it wouldn't mean anything.

AC: Things like the last call time was it critical that that was in text?

KF: Yes, there wasn't a symbol that we could we did later.

AC: And the number key pad the numbers had to be there because that was the way…

KF: That's the only way that the customer has to interface with it, the person who uses the service uses it through a keypad.

AC: So presumably if you went for the screen based one you wouldn't need that keypad?

KF: No, just touch it and drag it, and it would send the codes, you could probably hear it but you weren't typing in the numbers any more.

AC: Does in this instance the three dimensional aspects exist within a 2D world, or do the 2D aspects exist within a 3D world?

KF: You've got both, 2D inside a 3D, 2D on top of a 3D and the 3D is within the window of a 2D machine. Doesn't confuse though, I don't think.

AC: Were there specific ways of avoiding the confusion between those.

KF: It never ever contemplated as being a problem, it's a bit like the guy who invented the mouse - He said he didn't know it was difficult. It was never even contemplated, we did what was necessary to create, we weren't trying to stop using or start using anything we just used the bits that worked.

AC: Can users change the information that is displayed to them and sort of what level of change can they exert?

KF: Very, very, little at all, the user.

AC: In terms of the amount of control that the user can exert…

KF: Very little at all on this demonstration, none. I would say the only thing they could do is change the viewpoint. But you've got to get the user and *user* right. The user of it is demonstrating to somebody else.

AC: The person who is interacting with it

KF: Can move the viewpoint.

AC: And would they want to do that?

KF: It doesn't add anything to the explanation at all, it's basically a fixed animation in front of you. So what was happening was that these objects were moving like that, forget it I will just reset the world.

AC: Can the person who is interacting with the interface change the interface? You demonstrated before how to add a new piece of code.

KF: Only if they had the toolkit. it wasn't built into the demonstration.

AC: But it was intended that the end user the customer would be able to change?

KF: Yes yes it was intended but we never had the runtime demo of building things like that I hadn't learnt how to do it. It would happen yes.

AC: How interactive would you say the interface is?

KF: It is extremely interactive in the sense that you perform a function like invoke a call and in comes a call and it does things and when you click on the handset it does handset things. Yes, it's quite interactive like that.

AC: How would you characterise that?

KF: It has a logical visualisation. Which, rather than, you don't have to drag everything around you press a button or you put a phone down and other things start to happening so its interactive like that you don't have to push the call down you don't have to do this or that.

AC: Is the interface immersive screen based or

KF: It's screen-based its Fish tank VR.

AC: Why was that chosen?

KF: We didn't have the ability to programme the immersive equipment and I have a personal dislike of immersive systems if you are trying to teach somebody or show somebody it's very difficult.

AC: So that's one to one, computer to person.

KF: Or one to twenty we used to have crowds of people round there, a few years ago it was novel, it doesn't look it now. But it did then, its certainly not immersive it's hardly VR it's just three dimensional animation.

AC: If you could describe ways that the user can navigate the space?

KF: There is no navigation.

AC: There is no navigation at all, some of the things that I have here, are: is there is free movement?

KF: There is in three axis it adds nothing, its there.

AC: Multiple vantage points

KF: Yes, whoopee.

KF: Not used in this one.

AC: Fixed paths?

KF: It's possible to put them in but they weren't used.

AC: In terms of this has been described by some as action concepts, metaphors in which you can interact? So they have described move which includes, navigate, fly, drive...

KF: You can do all that but it is not used in the demo. The software is capable this thing can fly around, I can add click on and fly to, to it, it's not used to demonstrate it. The one thing that is used in here is distancing which is a VR concept you see the keys that's to speed the rendering.

AC: Interaction descriptions include Pointing or touching or circling items and so you have a cursor there you use that?

KF: You would use it to pick it. To pick up the handle and things like that.

AC: Would you use the superscape control to fly around?

KF: No activation on that. They are purely viewpoint modifications that's all they do they move your viewpoint around. The other standard mouse is used to activate or drag things.

AC: Is there any means of delete or throwing things away?

KF: No, there is a reset the world which is the most important thing in VR ever invented. Reset the world, bang, and then you carry on.

AC: The input devices that you have, did it use the keyboard at all?

KF: Yes.

AC: In what ways was the keyboard used?

KF: O' no on this demo, no, it is not used at all other than reset the world.

AC: Is the space mouse used?

KF: Yes, or you use, well the control bars on the bottom here never existed when it was developed, or you could use the keyboard fly buttons by holding shift down and you also have this function which is a space bar and an ordinary mouse flying.

AC: And so at that time it was using?

KF: I used the space mouse most of the time and we could use these buttons as well they are disabled now, but when it was a dos application you could use those as well.

AC: In terms of the envisaged customer user interface?

KF: There would be no flying they would be able to rotate a viewpoint, they might have had click on and fly to, but it was mainly as a cheap animator. Instead of storing animations you stored a world and then you moved around the world which was much more software and memory cheaper than storing massive sets of animations.

AC: In terms of navigation would you say that the interface is hierarchical in terms of the way the information is put forward?

KF: No, I would say that it is practically random. It was generated and then found easy to use by people who knew how to use it, there's nothing in there that would tell you how to use that.
So there is no hierarchy there at all, you've got to know what it is but once you know it, it is terribly simple. There's only about three things that you can do.

AC: So there's no kind of obvious path through it?

KF: No, a person demonstrating it has a definite path but no obvious path there's no set of buttons along the bottom. It was only going to be a visualisation of a way forward and what happened to it was that It got left there it was never going to be the end result, it was a means to an end and it stayed as a means.

AC: In this interface were hyperlinks used?

KF: No, I put them in afterwards to help me when I'm demonstrating, you click on these and it jumps to another world. It was never part of the visualisation itself.

AC: Networked information might flow

KF: Never, It was never networked never, never you have got to think of it in the days of dos on a stand alone machine.

AC: In the terms of information that might flow as a hierarchy

KF: There is no information flow there at all.

AC: Could the user go back in time in the sense that you might use an undo feature on a computer?

KF: You could reset the world. There are only three functions in it.

AC: Would there be any other mode of interacting with the information, you mentioned random which I hadn't got on my list?

KF: No, It's a fixed path but what I meant by random what that the way in which buttons was created and placed was randomly created it boiled out and we threw away the pieces that were not of relevance there used to be a lot more on there and we got less and less you know we had a whole telephone with all its functionality on the screen and it wasn't relevant because we weren't modelling a telephone we were modelling a service. We only needed enough to get across the idea. We didn't need the flex and the display and the tilt and the display it was pointless.

AC: Was there a process by which you took things away and thought that's important and put things back?

KF: No, we started by trying to visualise the real thing and realised that wasn't working and started again and binned all that and did this.

AC: What was the reasoning behind the mode of moving through the information?

KF: It was purely the logical sequence that was being show in the brochure the explanation broacher, so we tried to mimic exactly the sequence that was being shown in the broacher.

AC: Did that constrain it in any way or was that useful?

KF: That was the only way anyone had of understanding the services I didn't understand it from any of the other things I read but I did from the brochure that human factors had produced the instruction leaflet.

AC: In terms of what has been described as kineasthetics, this relates to how a user who was using this understands where they are in terms of the potential of the space their notion of space,

KF: It really has no intentions to do anything like that this the intentions of this were to have an easy way of doing an animation, and out of it grew the fact that it was actually a virtual world any other things pretensions that virtual worlds have since then weren't even contemplated then. We were still exploring the medium, prior to this they were doing kitchens with doors opening.

AC: The user doesn't really explore the space?

KF: No, we were using it purely as a cheap animator. But, after that we realised some of these things, but they weren't applicable to the problem we were trying to cure. Amanda's demo uses space better.

AC: Animate parts there is the animation what different aspects does it show?

KF: There were two or three aspects, that a button is activated, a call arrives and that a call sits somewhere and keeps going on ringing until it is answered. Which currently is only a sound and then when it answers it changes state which you don't really get that it drops from a-b the third thing is that we added the mouth to it as it is a person, it's not a line between two points it's a person talking to you. And the third thing we added, I don't know if you got it there, was a bit of slip to it, when you put the call down it drops down and talks when another call comes in, we added fun to it as well, but we also, when you change and put it on hold we gave it another state, but you watch it when we move it, it slides across. And the reason behind that was that when we didn't put that reality reaction in it, it looked dead it looked absolutely dead, and so we put that slide and resistivity in it. So as you slide it around now they actually slide around on the tray, and that made it so real. Compared with them staying in a fixed place. They looked as if they were part of the tray when they were attached to it and that was wrong they were little calls. It's so simple but that animation made all the difference. It actually came by accident. Now that people understood and the fact that it drops away.

AC: It has human characteristics would you say that it has emotion?

KF: By accident that little shrinking one. We were going to give it more emotion but it had enough the fact that it was shrinking and dying away and we didn't have to say that that was consistent.

AC: Human or mechanical?

KF: O' they were human. It was a call and a call was a person not a link between two places. Flogged that thing to death but.

AC: What real world characteristics did the interface employ?

KF: Gravity, it used resistance you know, slip, and it used cartoon flashing arrows and it used a real handset. The most important aspect it used was sound, you turn the sound off and run it and it is as dead as a dodo.

AC: Did the animation break with real world conventions?

KF: No, we did have it going up, it didn't work, a call comes in you see and so we had it coming up and then it met one coming down and it all got very confused. So we have always had it just disappearing, the other thing is when the second one came in and you got rid of the call there was one thing I know this sounds like knit picking, doesn't it but, these were quite important when we were playing with it when you did that, you got rid of a call, you could have just made it disappear, and you didn't know where it had gone then, so actually we made a trap door open and it drop and only disappear when it is out of view.

AC: Right so like real world objects don't just disappear they have a path.

KF: It had a path in and it was gone.

AC: And when it disappeared out of the bottom of the screen do you think people just forgot about it then…

KF: Yes, they do completely.

AC: ...So long as it had a path to leave. It went they didn't care to understand where the calls were coming from either.

KF: The person the other end is still there you seen, even though the call was finished, the person hadn't disappeared and they had just moved out of view, and it wasn't thought of like that, we didn't do it like that but we ended up doing it like that because it didn't look right, it wasn't deep thought it just happened, you know.

AC: Some things offered themselves as more suitable answers?

KF: It was easy to do on the software. I mean I could have made it disappear but it wasn't doing what we wanted it to do.

AC: The next questions I have relate to presence of the user.

KF: There is no presence, here you are a participant not a present.

AC: Was a generic style intended in the visual appearance?

KF: No, it was, let's get this idea together, O' it works and that's it.

AC: I suppose the style you have is based on the facets?

KF: And yes, what was available clip objects we didn't build anything specially for this, the arrow came out of a library the telephone came out of a library of objects it was just how it was configured, in fact that's not true the only thing we did build was the chip to keep the software in, we did have a call store so you knew how many calls you had, but that was never ever really featured, and this had three draws on it.

AC: Was it always clear what kind of visual representation should be used?

KF: No.

AC: How were the decisions arrived at?

KF: I was driving it, I did it, I was the decision maker of how it would have looked.

[telephone call interruption]

KF: Ok, here we go.

AC: I think we could probably finish this off in about fifteen minutes?

KF: Easy. Away you go.

AC: I guess the last question I asked was to do with the generic style and polygons and things like that.

AC: Was it always clear what kind of visual representation should be used?

KF: No, it was real innovations stuff, not just me but us playing with it, it's the sort of what you would call a coffee club type thing. Like, how on earth do you represent a call was the biggest thing? Once we had represented a call we had to move it around and as I said a lot of clip art was used and so we used the Lego that was represented in the tool, and this was to be the beginning of moving to the next one. I think it's relevant to see what Amanda did with this.

AC: Ok.

KF: Shall I load up that?

AC: I think if we stick with this. Finish this one, and in a sense we can ask similar questions of the next one.

KF: Ok.

AC: So were some aspects easier to represent three dimensionally than others?

KF: Yes, a Telephone rather than a call or a piece of exchange software - Telephone was a doddle.

AC: So the ones that were easier to represent were the ones that had real world counterparts?

KF: Yes, definitely.

And, in making the ones which didn't have real world counterparts, how did you go about that?

KF: You started with a cube, and if that worked you were ok and if it didn't you had to add a bit and that's why there's lots of cubes in there.

AC: If we talk about mental models. Do you think that mental models were used to link the information on the screen?

KF: This is all about mental models, there were no consistent mental models for call waiting and I believe it's a bit presumptuous, but those people who have seen this model remember it. And it was a dawning to us that were playing with it that this was really visualising mental models and that was what it was all about.

AC: Was that something that came about as a by-product of it: it wasn't intentional at the start?

KF: It was a by-product. And then It became the driver for a whole raft of work, mental models were the sort of a buzz word then, they had always existed, I mean I worked on them on pagers, but I never had the ability to animate a mental model other than in my head and this gave me an ability to animate mental models for others to see.

AC: So when you were creating this one were you creating your own mental model?

KF: No, I created the mental model and then built it, and then building it showed constraints and so I, it reflected back. I would say.

AC: And then the mental model changed?

KF: Yes it did. I think the problem with the mental model was that it didn't have, a, a mental model didn't have, any bounds and this doesn't have any bounds, but at least this has a horizon your model didn't have any, it wasn't, it sat in space didn't it, it doesn't have any horizon or position, in your head.

AC: And you say that was a problem, in what sense?

KF: Well to begin with we put this in a box, because it didn't feel right having it sitting out in the infinity, do you see what I mean, you went to call waiting and then you opened the door of a box and there was call waiting in it, and that was what we did originally. We didn't need the box, it was irrelevant but we did lots of work it's like the simple things left behind but we have thrown all the garbage away, I don't think any of the early models exist.

AC: Is text used on there to narrow down some of the meanings?

KF: Yes, last call time.

AC: Was that obvious when that would be used?

KF: Yes, blatantly obvious.

AC: Are any of the objects named specifically?

KF: No because we used them to mean anything like whoever you were talking to.

KF: Not ambiguity, No ambiguity every thing had to be explicit but what it didn't have to be was specific, the other one is highly specific.

AC: In semiotic terms they sometimes call that Floating signifieds where you can float words.

KF: Yes, yes I don't know that term.

AC: If we could just talk about the audio side of things. Was a generic style intended in the audio content?

KF: No, it was what was available.

AC: Is that pre-canned stuff, clip sound?

KF: All pre clipped sounds. Yep.

AC: Did they have their own particular generic style that you could describe?

KF: No.

AC: Was it clear what kind of audio cues should be used?

KF: Yes, it was blatantly obvious. First of all, the phone ringing and the second was the sound that came from the system when the call waiting was working. Yes.

AC: But as you mentioned before there was a difference between sound that the actual system

KF: We used the sound the system did and it didn't mean anything, and so we put in a sound attached to a moving object that did mean something and a lot of people who saw it said they wished it did sound like that on the system because then I would remember the mental model and they used the sound as a mental model trigger. And we asked the exchange if they could put that sound on instead of the current sound and all the exchanges around the Country don't have the ability to put that quality of sound, they do, but you would have to use a sort of pre-taped or stored memory instead of just sending a signal to a tone generator. 'Boing' was a multiplicity of sounds, isn't it, not just a tone.

AC: So, different alternatives were considered earlier but the final one..?

KF: Only once, we used the original tone, I think we spent ages trying to record it and it was pointless.

AC: Is that the only sound that is involved in the interface?

KF: There's two sounds the ringing is American ringing, yes, because it came with the phone, its not British we tried to bring sound in but I didn't have microphones I didn't even know how to get that in at that time, I do now it's a doddle.

AC: Would you say that the audio cues were from real world or from convention?

KF: Real world, O' both, the 'boing' was convention, the ringing was from real world. You could have used an awful lot more sound and Amanda did, it's lovely she used a lot more sound, it adds to it.

AC: What value did the audio give?

KF: Vital.

AC: Was it kind of action intention feedback instruction realism,

KF: All of those, all of those, it was remarkable, you see this thing without the sound on, on and off, and the difference is four times better with the sound on.

AC: Why do you think that is?

KF: Because we are multimedia human beings and I was using real world things all of a sudden there was a phone ringing and that wasn't ringing, once you put the ring on. It became more real phone. When an object was hitting another not making any noise, once you made it make a noise it became more real.

AC: Do you think it was more important to have sound with the concrete real objects then because they had sound in the real world? Perhaps less important for the ones that were abstract anyway.

KF: Yes.

KF: The abstract had very little than being a cube by using sound you could actually give them a function, like I've got some in the emotional icons spikes you hit them and you stop, your viewpoint stops but the sound goes 'dooing' metallic, if that was a squish it wouldn't be applicable.

AC: In a way, squares don't bounce, but with a sound they sound round.

KF: Yes, maybe you are reading more into it than I am. Yes, we did do round ones later, Amanda turned the calls round.

AC: Was the sound three dimensional?

KF: Yes, but that just came with it, It wasn't used.

AC: The sound wasn't used in any way to orientate you spatially?

KF: No, because you are fixed viewpoint.

AC: Is there anything else you want to mention about sound?

KF: It surprised me, I thought everything was visual and when I came to do it the most powerful thing that was added to it was sound and In fact that lead us into having our own sounds designed for other systems Amanda and I commissioned a musician to write our own sounds for the next version of call waiting, and we've got a library of them.

AC: Do you think that the interface would have been effective as a sound only interface?

KF: They tried a sound only, I think, in the past, because it had to be speaking and then noises and it didn't mean a thing, so it was both.

AC: I have got some questions to do with user trials were any trials actually undertaken with it?

KF: Not officially, a lot of people have seen it, both Amanda and myself and the project manager had gleaned opinions and whenever I have shown it at a big conference we have had an amazingly consistent reaction to it, in my opinion not being a forum moderator or anything, but they seemed to me to be very consistent reaction to it.

AC: What sort of reaction was that?

KF: I could use this to explain something else, they came away with o' I didn't know it worked like that, O' I understand, and the other thing was I never thought of a call as an object before, that was the one that was mainly BT internal and now people talk about a calls as an objects. But I don't think it totally stemmed from this, I think it was time when several people were thinking like that, do you know what I mean, lots of people come to the same conclusion at the same time. I think it was a way in which people were storing calls, forwarding calls, manipulating calls, there was a, just after this there was a student at central school who designed that answer phone, real answer phone, made out of balls after this and before Amanda did hers, version of it because it was probably a year between this and Amanda doing her version, a guy called... I want to try and give him credit.

AC: The other chap who did it was Durrell Bishop.

KF: That was three, four years later at the Royal College. I've got his work and I would like to give him credit for it because he did come up with it.

AC: Do you think that the people who use it would need to understand computer conventions?

KF: No, no.

AC: They would be relying on real world conventions perhaps?

KF: Things they picked up from a kid. That was the whole premise of emotional icons it was to go across culture. Just like lifting an eyebrow on a Disney animation, round the world whatever the age they would understand, no training. That was behind emotional icons I'm not sure that would apply to call waiting, but some of the things in it came from.

AC: Would the audience perceived to have similar cultural values as the people who designed it?

KF: Yes, yes of course they were I have no other way of receiving cultural values of anybody else other than myself. You could say I tried, but no.

AC: Did, you mentioned before about comparing text version of it to using the mental model version. Was any kind of formal trial done on that?

KF: I think some of the people doing the text version showed it, It wasn't done formally, maybe five or six people were shown it and say is that what you just think, o' yes it is or o' no it isn't, or o' I wish I had seen that before. There was lots of that kind of comment. I can't remember who did it. It wasn't me who was demo'ing it either. Because it was just around it was a demo that just, just.

AC: On to the conclusion parts now, what would you perceive to be the main successes of the project?

KF: It kept me funded that year, (laughs) no, one is that it was used totally out of proportion to the amount of time that it took to create it. That it led on to Amanda's work, and Amanda's work did change the way that telephones were laid out, to reduce confusion for customers, that was a spin off. The other one was that it made people think a whole lot more about what we could do with a screen phone, because up to that point they had been duplicating in text on a screen phone and the first ADSI screen-phones were all text phones which weren't addressing the problem. And I believe it was one of many projects that pushed people, many projects, pushed people towards a graphical 3D way of using services rather than text based way of. So, it was like trying to get a GUI onto a phone. It was one of the things that helped push a GUI onto a phone.

AC: And a GUI is?

KF: Graphical based user interface instead of a text based user interface.

AC: What would you perceive to be the main shortcomings of the project?

KF: It didn't get an owner, in the business where it could have had an effect. And the reason was that wasn't the aim of it initially, but for the company to benefit from it it needed to have an owner other than just as a research demo.

AC: What would you say the main advantages of a three dimensional were?

KF: Speed, I could generate an animated sequence in seconds by giving something bounce, you try and do that with a set of cells, you know, and I could vary the rate of the bounce so the 3D world was, the other thing was that I could set my viewpoint whenever I wanted if I couldn't see all of the elements that I had built together I could readjust the viewpoint. This was for setting this as an animation we were not using 3D other than as an animation package in this case.

AC: The alternative animating software would be?

KF: A nightmare. It was cell by cell rendering of each cell on a PC probably as wire frame with flat colour, so that's what was around then if you wanted to go to anything more than that then you would go off a PC and you would go onto a mainframe or a silicon graphics and they needed acres of training to get on it. It could be done we had the ability and the skilled people, but this project wouldn't have justified it, it was more important to put that skill onto something different.

AC: And do you think that the advantages?

KF: They are general advantages for visualisation, if you can get visualisation straight out of the person having the idea, rather than via a technician be they a programmer or whatever. Then you can give the creator of the idea the tool and then the other thing you can do is take the time between the idea and the creation, shorten that so instead of having to carve something its there instantly then that's the other advantage. Because then you can then change and change and change and that's what I found was lovely about doing it and I think that's what keeps you going the tool was non tiring, and highly creative.

AC: What were the disadvantages of using 3D?

KF: The user interface was rubbish, and you as a designer wanted to spend your time redesigning to the interface. And what was really funny was I was trying to design easy to use interfaces on a tool that had a terrible interface, it was a certain irony that the tool was appalling bad laid out but had the functionality that I wanted. That was the frustration. It wasn't consistent was the upsetting thing, I don't mind it being bad or difficult to learn but when the thing wasn't consistent in its abuse, when it got things wrong it got them differently. You were 90 percent of the way there and then it didn't work.

AC: Do you think that...

KF: The tools have improved, out of all proportions.

AC: Were there any guidelines promoted through the

KF: No, I think it is a very closely knit field that we are working in, people who could influence saw it, that's all you could say, there's lots of people who know it and that was all it was supposed to do. It hasn't been built into any guidelines. It has put a spin on, I hope, it has just put a spin on the way you look at things, does it the way you look at things? I mean that's what the icons did it put a different spin on the way you look at things.

AC: That leads things forward the thinking of the group?

KF: Or, they don't like it, I, the thing that Amanda wanted to do was completely different which I think was great. But, because before there wasn't anything, now there was one, now you could build something better and different from it but before that, call waiting, there wasn't anything not that I know of.

AC: If you could explain it as a demo and add anything that you want to add, I think that is probably best, there's no point in going through everything again but, if you want to add anything that has changed in relation to the previous one that would be useful.

KF: You will see the difference, there we are, first of all the user interface is now a telephone.

AC: Was that scanned in or photographed?

KF: Scanned in, photographed and then scanned in. She then used, these were the six services and so she was going to have a button for each service, so in this case you instigated in this case call waiting, so they were going to be the other services, and then you clicked on the buttons, and there's a time, you see the call comes in, and then when you answered it you lifted a real phone and it changed view, that's not rendering correctly. It's not good, it's because it used the old, could we start that again?

KF: Let's see if we, O' good, so it is there, this is an old Visualiser I hope, are we still running?

AC: Yes.

KF: 'C' waiting, this is Amanda's; it may not work on here.

AC: this is the one which we would call visualisation two.

KF: I'm not sure its going to work, yes here we are, and she got rid of the mouth and made it a breathing sphere so lets reset that and it works and basically she had it here so that you got six services and we were going to build one after another there. And the model there is capable being modified to do all six, of five of them as I say, there was call waiting the call would get caught and could go in one of two trays, like the old one, so in would come a call from BT, 'boing', it would ring you lift it by clicking on the handset, she used an awful lot more sound and we had these done, and in would come a second one, right, and it would change from that and then when you pressed the recall button this was the layout of a real phone, and then two, and it would hop around getting angry and she could get him to get faster, and then recall 2 would talk to it the other one, recall 2, and then when you put the phone down, it would change the way it jumped. Right, and this proved that on the telephone the recall and redial confused people considerably and they are side by side and you would get people using them completely wrong, redial dials the last number. So that primary thing, we saw it here we checked back with the people and that changed the style guide. So that never happened again, it was on that particular phone and they hadn't realised that it was a real problem.

AC: Why was the telephone in a separate space to the three dimensional world event though it was three dimensional?

KF: She wanted it to be a BT phone and that's a photograph and we hadn't modelled a real phone.

AC: If you had have modelled a real phone would it have existed in the 3D space do you think?

KF: No, we were keeping the two apart now. Because this was doing just, because this was actually does an awful lot more, than just, this was to have, when you came into another service which is call divert what would happen was this would come in here and bounce, and a little ring would spin round this shaft which was how long you had it, the timer, right which would be telling you how long you had set it, you could drag it up there and that would give you longer before it would call divert, right, that was a setting device, we didn't create it because we ran out of money and time, but her animation sketches showed it running round and round and it would drop and when it hit the bottom it would spin round, spin the object around and then the call would drop and would be diverted off to another call. And this would now be here ready to accept another call so that was call divert on busy as well, so if this one was busy, you couldn't get through, it would automatically call divert and so all the services were being built round these and the telephone here wasn't relevant, it was just a thing to pick it up and put it down, and press buttons, so we had got the telephone there.

AC: The visual on this is, as you said before, is quite different it doesn't have a horizon, is there a reason for that?

KF: Amanda's choice. It does have a horizon but in this view we're not there. So you did see the horizon, but only when it went to different, she's got it somewhere, doing different things, spinning, but she was learning the software, just joined the company, learning the software. Then she came up with that, and she worked out a whole way of doing it, and what's interesting was, for me, is that she hid everything underneath, that floor, That's all her code and she colour coded all her code, so each of those is a little box with a different piece of the code. So like my chip thing she actually put her code in little boxes and had the versions by different coloured stripes. So she kept things in different places it was very different, so you can see why I got excited about it, it was really professional, really professional. And she had got all the things she needed to build the like.

AC: And how difficult is it to put in the 2d flat screen in front of the 3D screen?

KF: It's a doddle.

AC: And you can programme that flat?

KF: Yes.

AC: Is it hotspots?

KF: No, its just a, if you imagine a theatre that's how they see the Superscape world, so you have the curtains and this is on the curtain level then there's the background, then there's the stage inside it and then there's objects in it. So this is part of the foreground this is the background these are the objects and they have a place to sit, which is the stage, so, and the other thing is you can do that multiple times so you can have a windows in here with all this inside that window and a window with that inside that. And you can do multiple 3D windows but only one of them will be rendering at any one time. So the others will be a view. You only move the viewpoint in any one window you can't get it to move the viewpoint in four windows, well I haven't yet, you probably can now.

AC: How was this received differently to the other one the previous one that we just looked at, was it received, well how did it relate to the other one is more what I am saying?

KF: We were trying to commercialise it, to take it to that audience. We were moving it nearer the customer, and that was Amanda's brief, was that mine was a great for explaining it to that person. But we wanted the customer to play with this...

AC: And relate it to what they recognised.

KF: Well what were going to do was get it to run a sequence and then get them to repeat the sequence.

AC: So like Simple Simon?

KF: And it never got that far. You could ask Amanda where it got to. She got seriously fed up with it, because the software was *so* difficult to use, she was being asked to do something she didn't really, to understand the other services is really difficult.
And she hadn't built mental models of them, I had built that swinging model, and she was having an awful lot of difficulty there and she was trying to run several projects at the same time.

AC: It's almost like being an engineer when you are creating a canal system with water flows and everything else trying to work it all out as a mechanical thing that hasn't existed.

KF: And the tool was no good, you were trying to dig it yourself with a teaspoon. That's what she felt like, she got very down with it, so we took her off it, because that wasn't what she was there to do, she was there to bring inspiration and in fact what she was trying to do was handle turning.

AC: It does look good though it's interesting to see how the two are quite different, but they are both representing the same thing.

KF: And I think that's lovely, I mean you know that's such a degree of creativity, the fact that that goes inside that is just a sorting problem, but some of her ideas are lovely. And the crispness of that, you know, and the fact that it gets in a muddle, you know, is because she didn't have enough time.

AC: So when we were going through it originally we said that this one had perhaps more of an angle on usability, commercial viability. But, when I mentioned challenging conventions you said the first one was. Was that because of time or because of content, is it challenging conventions?

KF: She was getting extremely conventional there.

AC: Right, it needed to be that conventional to…

KF: For the Simple Simon thing you said. Yes, that had to work like the phone, but this was explaining what you were doing, whereas before call waiting was just I do a sequence of buttons.

AC: What advantages would you say that this one had over the previous visualisation?

KF: Purely tuned to call waiting and it, I see this as the logical extension of the previous one. The fact that she decided to change the animations inside I thought was superb. Because the first one was dedicated to call waiting, this one could do all six, five of them we knew, and she has got sketch sheets to prove it, the sketch sheets are lovely too.

AC: I should have a look at them, are they still around?

KF: She might have burnt them sacrificially when it finished because she was not happy when she finished it, why it's unfinished is because she was, it was just a horrible tool and she wasn't enjoying it, she might tell you differently.

AC: Were there any things that were perhaps less successful in this interface than the previous one?

KF: I think its individual explanation of Call waiting was not as clear as the previous one, my opinion, but the previous one was dedicated purely to call waiting where as this was to do all of them.

AC: It became more generic?

KF: Yes, to gain the ability to do all five or six of them and loose a bit of clarity was fine. I didn't want to have six mental models. None of us wanted six mental models, as especially as they all used the same buttons and they just used them in different ways.

AC: Yes, and as the call remains the central thing.

KF: Object, I think she lost the call there going from one colour to another and squishing, it's not as much fun as the cube.

AC: It has less association…

KF: With a person. But you've got to be careful, I've always said that if you humanise things you have lost it.

AC: And it wouldn't be applicable I don't know if any of it would but, would it relate say to internet connections or anything like that.

KF: It could yes, but we were trying to get across one problem we were not trying to boil an ocean we were trying to solve the fact that we had got a National network that could deliver services and only 25 percent of the people who actually took the service up ever kept it and they were less than two percent, so we were only a quarter of two percent actually keeping the service, so it was rubbish.

AC: And that was perceived to be because it was a difficult interface with the service.

KF: Yes, nobody had a mental model of what it could, how to, well, once they saw that it could deliver, great, but then they didn't have a mental model to be able to consistently use it. And that hasn't changed, we've still got that out there and it's still charged for and it's still as bad to use so we haven't improved it really.

AC: This, you are suggesting that this was about a year on from the previous visualisation?

KF: I would say so. You could have to look at the files, the original files to find the date that they were created.

AC: Do you think that the software had changed in that time?

KF: Yes, not vastly different but it had started to change.

AC: So it was a different version?

KF: 2.5 to 3.1 or something like that, not a lot, not a lot.

AC: And that wouldn't change it?

KF: It didn't make it very much easier. I think the image editor helped changed but not a lot else.

AC: Would the objectives for the project had changed considerably?

KF: Yes, completely, we were trying to, well it was always six but we had only managed to do one, it was a service creation tool that we wanted, in the end it was a service visualisation tool and we had aspirations, and this was the final culmination of the aspirations.

AC: And this was where it ended?

KF: Yes, there was another aspect of this where there, its not here, just after this I did something called CSS which was a demonstration for the BTs system inside. And that used some of the sort of emotions stuff, as a customer handling interface, for the people who are the other end receiving calls from customers and they were having to handle the customers information and much of it was related to what services they had and we could use a visualisation of the service to say what the customer had, yes, like a mental model of what the customer was actually using.

AC: What services they had...

KF: Yes, so we could reflect it back that way but it was never used more than for one discussion.

AC: OK I think that that can conclude.

AC: I know it is kind of running on while it is fresh in our minds it might be work having a quick chat about process in terms of questions in terms of the timings.

AC: I don't want it to be self-conscious. We originally suggested that we would start at one and finish at half four.

KF: We started at two.

AC: And it is five o'clock so we are ahead of...

KF: It's quite a long time.

AC: It is a long time.

AC: One of the things that I was originally planning to do was to divide this up so I would maybe get you one morning or an afternoon and do the first part, the bits about where its come from and who's involved in it and I could then take that away and look at the background information and everything else and do the middle bit as a discrete bit so we could bring this middle bit down in time. So that it doesn't get laborious.

KF: I didn't feel it was laborious it may have been a long time, what I did feel was that it wants to be done a bit more privately than this, so you don't feel as if you, to do it, and then you can talk on and make comments. With regard to the demos and being able to see the demos, because it's all visual and you're doing a lot of verbal, I'm trying to do a lot of verbal explanation that a lot of visual stuff could do, because that is what it is about.

AC: Right OK, so you would rather talk it through more with showing? Do you think that the questions lead into that kind of description or do you think there is a different ways of phrasing them so that they will lead us?

KF: I didn't find any problem with the questions, other than time, I can't remember, I don't have all of the documentation, do you know what I mean, I'm not sure I'm telling the total truth. It may be, look a wonderfully planned programme in hindsight but in fact what actually happened, I can't put the sequences in, you are not necessarily getting the truth you're getting what was the perception after the event.

AC: And the later case studies will be clearer because they are more immediate.

KF: And they are well documented this was quite quick.

AC: And in a way it was a lovely visualisation and both of them are very interesting. They are nice because they are abstract and I like that aspect that they challenge some of the mimetic aspects of the interface. But at the same time because it is a historical thing, its quite a small project and all those things, we can use it as a pilot study and we can still use the information from it but it is more sort of.

KF: I don't think we would have got to where we are now unless we'd gone through it as a project. And a lot of what is going on in other projects I honestly believe is they are still behind us because they haven't putting the virtual chair into the virtual room and the virtual handset and found out that it wasn't relevant. There's an awful lot of people still doing that, now, the fact that I am working on putting carpets and curtains into a virtual world. I'm not knocking it I'm just talking about in my case you are buying carpets and curtains but to put a phone in wasn't relevant, you know what I mean.

AC: You only have choice if you have another option other than the reality model and so when you are doing the reality model with furniture you are doing that because that's the best way of representing that particular one, whereas if it had needed a more abstract visualisation you could have done that whereas some people are still trapped in the mimetic view where they couldn't have gone for the symbolic. So they would be like in one of the ones that I did struggling and ending up doing an interface where it was meant to be for non computer users and we had a laptop in the virtual world and you would go and sit at, you are on a laptop, and you are a non computer user, and you go and use the laptop. And those kind of things are because at that time the design team worked within a particular metaphor which trapped them and they said I need to hyperlink in a real world. I can't hyperlink in the real world so I have to go back into the computer and then hyperlink.

KF: It's not true.

AC: It worked for that, but it was quite restrictive.

KF: One of the most amazing things, I haven't got a copy of it, I don't think, but it was to do with the very first bit of the emotional icons work done by the guy who did the emotional icons, I might have the tape, what he did was he took two spheres a pyramid and a set of cubes and he laid them on an animation table, a rostrum camera, and he made them talk, right, and then the mouth or the cubes of the teeth walked away. And he kept the animation of the two eyes and the nose moving, and it was still talking. He then moved the nose away and the two eyes were still talking, we took one eye away and that ball was talking. Right, now if you run the film the other way around you don't know what the eyes do.

AC: You have to be pre-conditioned so its like the old lady young lady picture, if you see the old lady and then you look at the ambiguous old lady come young lady, you must have seen it?

KF: I think so.

AC: You always see the old lady whereas if you get shown the young lady before you look at the ambiguous picture you see the young lady. And I think there is a duck rabbit isn't there?

KF: What I was saying, was that we could use this, I think in an interface that fell apart, that's where my navigate world came from because what we did was we took things like clocks and you could take away it and all of a sudden you have got a tick and just two arms in free space. Do you know what I mean, but you didn't know it was a clock to begin with but the world could actually gut itself as it got more complicated it could gut itself. As long as you lived and used it you could.

AC: Still make the links.

KF: ...You could do your duck and chicken, duck and rabbit. You can do that more effectively and I thought that's why Amanda thought that ball would talk and it didn't, did it.

AC: I think on the emotional icons when you start with a screen and that falls away that little square that wobbles turns into a floating square, in a way that is a story

that you are telling a story from a passage from 2D to 3D but in a way it was on a flat screen there so when it all disappeared and were floating it didn't feel floating.

KF: In space, that's what I was trying to get across and I haven't found how to do it. Those were those intuitive that we already know. And I was trying to make icons that were intuitive and we didn't really get to use many of those or some of those things in call waiting were. Some of Amanda's bending stuff, her scraping, her, did you see him jumping up and down in the box? Was much better than my, and some of those things were beginning to work. And I was trying to build and alphabet and I am still trying to do it, of what they are so we could attach those to... Not to cut, copy and paste, because cut, copy and paste are to do with documents. We wanted the cut, copy and paste of data manipulation and I don't know what they are.

AC: Languages cut copy and paste letters the three dimensional doesn't work like that.

KF: Its brake, accelerator and clutch in a car, cut, copy and paste in a document what is it in a virtual world? And we are still looking. We have got a medium that can create it but we haven't created it yet.

AC: And that is the amazing thing is that it is the human imagination that holds it back, its not...

KF: It's not the medium.

AC: OK, so are you happy with the questions as they are?

KF: It's just that it's quite a light weight project to put that on. I don't think we went that deep even in the pub.

AC: Some of the middle bits I picked out questions because the questions here are very in depth for example I have tried to highlight the questions that were really, really important ones but here space I have broken it down like space and time representation in that because is not a three dimensional world it wasn't relevant.

KF: Time was relevant you know when we hit the button and the call disappeared it then because one had disappeared the exchange rings you back, we could have had it instantly, once you did one thing and some, the other happened, but we actually had to put a delay there, right, because the software would have allowed you do it instantly, because once you did the thing ringing you wondered whether it was the one that had just gone, not the new one, that was, time was used there quite a lot, sliding of that thing, it could have just jumped, we used time quite a lot, you run it on a fast machine and it doesn't work as well, because it renders quicker and everything happens quicker and it doesn't work as well so I think time was important, it was important

KF: Its like when you run my icons on a fast machine they look super agitated whereas on mine they just go gently and then just nervous or a bit worried or a bit calm. So you have got to watch it on that, it's not what you meant by time is it?

AC: Well I don't know I think the questions that I have got, I think that there are time issues that can be discussed, but the questions that I've got are me trying to dissect and cut up aspects of time, so I don't know whether these would left us trying to force the interface into the questions.

KF: I think it would because they weren't considered until we tried to, they weren't considered in the building of it they were artefacts that we were dealing with during trying to get it to work once we had built it, so we got all the artefacts in and didn't consider time at all, until we ran it and then O' time was a problem and so we then played with time. But they were never considered in the building of it.

AC: One of the things that I will do with the same questions is I will look at the interface in my own time and try and see, as objectively as I can what perspective I will take on this and there may be an opportunity to ask Amanda some questions also and start to compare all of them.

KF: I'd love you to ask her because I'm sure she has got a completely different view of it.

AC: The only way we can confidently say these are true is if we have some kind of consensus around the documentation and interviews and everything else.

KF: You will get more of that from our other projects rather than this because there were more people involved more exposure. But this one will be a test, talk to Amanda and see what she thinks.

AC: For example, here on time, the visual use of time how was time conveyed; realistically age deterioration, lighting, mechanically clock digital watches, those are less relevant to Call Waiting?

KF: Yes, time was never symbolically, was it? Things were given mass and they were given that's why objects slid around, it was to give it some feeling of existing, now if that means that it exists and it slides because it has a resistance and it has time takes to move it or whatever, time takes to move it to drop therefore it has an existence whereas if it moves from a-b instantly it doesn't. Mass and I think that would be how it would be symbolically showing time.

AC: I think the difficulty is in semiotics, this rose can have an iconic meaning that it is a flower or it can have a symbolic meaning that perhaps that it is a political party.

KF: O' I see.

AC: But the same rose can have all those meanings, so to try and break it up is quite difficult. And I think that by having a semi structured interview scheme, we will loosely use these just so that, and hopefully we can dig in. The important questions I have tried to draw out from it but the others are more leading. I mean there are questions about presence. For example, can users leave objects in the space can users pick up objects in the space? And it is difficult to ask them, I need to ask them of all the interfaces.

KF: You can't in this one, I think it is very important to ask them and get negative results or positive results. But you get a result on there, don't not ask them.

AC: It is as interesting the negative as the positive because if it is definitely is not across the board then that is as useful as saying that it definitely is across the board.

KF: You are making me think about it in a way that I have never ever thought about it, you are asking me whether I considered things I didn't ever consider, and they may be in there and you can dissect them out but they were never thought of at the time.

AC: The aim of the project research is to dissect them out but again it is not to falsely invent them in the process.

KF: I think I have got to be careful of because in the hindsight of what we have done since, then yes I have considered them and I can't falsely say I considered it at that time. I didn't.

AC: That's qualitative stuff that should come through from the interview questions.

KF: There were a lot of things that we did consider, but…

AC: I think that one of the original things we said about all the projects that they were done as a suck it and see approach and…

KF: Intentionally. Yes.

AC: That these evolved iteratively, does that make sense, over time.

KF: All of us have worked iteratively for years and got…

AC: To reflect on it and to try and draw out some trends that would be useful to build upon so I don't think we are expecting theses things to be present then in any sense but if we can try to draw them out now in a reflective sense then that might be useful so it might be you saying that was definitely not there, that was definitely there.

KF: Were done.

AC: Do you want me to leave this with you or are you not going to have time to look at them. Do you feel that the questions are coherent enough?

KF: I'd hang on to them because one of the things is I think they should be a surprise every time rather than spending hours cogitating about o' yes I really did do that or didn't do that. Or trying to pre-answer them or order that my answers, that's not what you want.

AC: What I want is to hear your view and for these to spin off thinking, not to answer the questions for you.

KF: One thing would be to say I am a third of the way through I'm half way through, I'm two thirds of the way through, I'm three quarters of the way through, while you are going through it so you have got some idea of Is this going to go on for another hour or half an hour? Because it won't just be me you will be Amanda and the others, Mary.

AC: Is it worth me streamlining some of the bits…

AC: The other thing that I haven't mentioned anything about and this is any alliances and that would be more important in things like 3D retail. Because I have assumed with this that it is just BT I haven't asked about any other parties involved. And Patents are the other things that I haven't mentioned.

KF: It was early days in those days. We didn't really think about those things. Patent was a spin off and was a very useful spin off to say that we have a deliverable, alliances with anybody else we thought we had got an edge and we weren't going to give it away to anybody. Not until it was patented and then we could talk about it.

AC: I think that we may find some surprises. Confirm things that we were already expecting.

CONCEPT 2010 CASE STUDY TRANSCRIPT

AC: Today about the concept 2010, do you want to run through it as though it was a demo as though you were explaining it using the interface?

KF: Right, what we tend to do with concept 2010 if, give it a bit of history, shall I and then…

AC: I can ask the questions after, or we can kind of run through the demo.

KF: There is not a demo for concept 2010, what we did was we used to run various demonstrations on the concept 2010 desk and the whole project was about, concept 2010 was about a trading environment and 70% of the what we had to show was physical object. 30 percent were systems on the desk and my bit was futures systems, but, I brought together the original ten or twenty pieces that already existed in the labs which were, became concept 2010. So I knew that Dave Heatley was working on this and so and so was working on that and we had loads of disparate projects and I was working with the finance people and they came up with the idea, gosh we could pull this all together and build a trading desk of the future and I had also done a patent at that time I was one of the co-authors. The idea came from one guy, Michael Gell and there was another guy I can't immediately get his name, who I worked with and he and I and Dave Linton put together this patent, Michael Gell has since left the company, and that was about virtual trading. So there's many, many aspects to it. You have go the book on concept 2010, yes in there, there was a sheet with about 20 pictures on it, that was the crucial document because that's where I took 20 ideas, that the team up in global finance bought in, and it was from there that the desk was built mainly by them.

KF: Right, do you want to fire away with some of the questions? And then I will bring what relevant demos there are in.

AC: So the project title, is currently 2010, is there a history to the title?

KF: Basically, we called it future desk in the days of the, I was working on something called future desk, which was a desk of the future, office of the future, it then got called a glass desk after that, because we were going to have fibres to it and because the fibres took up no room we could make it out of glass and you could see that there was only one fibre coming to the desk. So we were going to build a glass desk that you could see there was nothing in it. And then we got rid of the fibre, by having optical link to the desk, through the air instead of by a fibre and it then became the dealing desk of the future, right, then dealing desk of the future became dealing desk of the present, right, like the things that we could offer now. And Concept 2010 which was this desk in ten, twelve years time, right and there's two, it may be exactly the same desk but ours would be showing concepts that you would get in the future and the dealing desk of today is actually showing today's products on the same hardware. Do you see what I am getting at? So Concept 2010 was actually a dealing desk of today but with tomorrow's concepts on it.

AC: Right OK, when did concept 2010 start?

KF: About three years ago, O' 2010 as a project, about two years ago, just before innovation '97.

AC: How does that relate to other historical projects within BT?

KF: It relates to about ten, different projects first of all I was doing one called future desk which was for an ordinary office environment. And I did that as a talk about what we could possibly do in a desk of the future and that didn't go anywhere, other that a bloody good talk and a few bits of hardware. And then there were lots of projects like optical cordlessness, things like a touch screen trading desk, at the moment they have turrets with buttons and lamps on them and they, Syntegra had, which is the trading desk part of BT, Syntegra trading systems had developed one which was a touch screen. And then they had a thing called open OTS, which is Open Trading Systems, in the past they would write bespoke software to run on a desk and they had done a windows '95, windows 3.1. version of this, so that you could have multiple information and also here at the Labs we had got 3D sound which was part of it. If you have got traders, foreign exchange traders, they used to have things called voice boxes. And they would be a private wire open to a particular person they would have up to eight, ten of these boxes and they could be shouting at them and listening to them and they would be eight or ten of them trading and geographically they were placed on the desk as if they were people that they were talking to and so they would go buy sell, sell, sell you know like that, and what had happened was if you wanted to add a ninth or whatever you had a problem, and there was a project that devised, using stereo speakers, the ability to spatially arrange across the audio space in front of you as many or as few as you like. Yes, and that was another project. What other, If you go through the paper work you will find about, O' we were looking at cordless ear piece, headset, handset, most of them are tied to the desk and we were looking at cordless radio or optical systems, what else, there was two or three visualisation things that I was involved in one was data visualisation, the other was information visualisation, which was taking that data and making some information of it, the third was to have a three dimensional way of navigating, Windows 3D, for navigating all the different systems on the desk so you didn't do it through windows you did it through a 3D interface. And the fourth one was a way of, another two, the fourth one was to do with the spatial audio. So you could drag cubes or people up and down the desk and their audio would match to what you could see on the screen, yes, so you could rearrange people and you could hear the audio change around the desk, because the set-up system for that 3D audio is a windows interface and it is terrible. And the other one was that we were looking at video conferencing, of multiple video conferencing through a 3D world as well, so what you would do is you would get hold of an icon of you, off a shelf or whatever, and put it into a virtual room, drag it into a virtual room, drag four or five people into this virtual room. And then fly your viewpoint in to the room and that would set up all of the calls and as the people were arranged around the table so the audio would appear in front of you and their pictures would appear spatially arranged inside the world in front of you. But those were the demos, so there were lots of bits and we didn't have central platform to put them all on and that was what concept 2010 was.

AC: How did that relate to other work that was going on outside BT perhaps?

KF: We tied in very closely, the 3D audio at that time came from Edinburgh University, which came out through their sort of, what would you call it, commercial wing. We were tying in with lots of different companies; Microvitech and Hitachi did the flat screen displays, Hitachi I think did the display, Microvitech did the housing and the drivers. They're on the concept 2010 desk and have you seen the copy of the video?

AC: Yes.

KF: Yes, the dealing desk of the future, that shows the very first prototype working for real, none of that was chroma-keyed, we couldn't afford chroma-key, so all the pictures on the screens were really live, superb, and we had to drop in inserts and actively switch in PCs. It worked on a four screen driver off an ordinary PC it was a twin 133 Pentium, running a four screen driver that drove that real desk.

AC: What is the relevance of the work in relation to other work within BT?

KF: BT has 40 percent of the world trading room market, this is *core* business to BT, very quiet, very profitable and we have considerable knowledge. There are three aspects to trading rooms; audio, video and data, and out of the Global players we are the only Global player that can do all three integrated, Reuters can do two of them, I think Dow Jones Telerate can do another two and there is another one Nightridder can do two. But we are the only one who can do all three and offer it over our own global network, and we offer the equipment at the end, everything, turnkey, come up with the money, and we are really the only people who have a research unit, you know like us. Reuters have a very good research unit but more in information management rather than some of the things that we do. Technically they are very good as well. But, so our main competitor are Reuters but they are also one of our major customers so for network provision, so you have to be a bit careful there.

AC: You have kind of illustrated that it is a part, a way of gathering together lots of smaller projects and?

KF: That's what it became because we just did it like that because we found that we could use all these different things that were being generated, I was trying to hoover up. Graham Walker was involved as well, who now runs the shared worlds campaign. Graham in those days was doing exactly the same thing, trying to hoover up all of them, point at something real and do something hard.

AC: Is the project part of any larger projects?

KF: They don't get much bigger than concept 2010, other than in money, it's not got loads of money but it has got loads of scope. Anybody could do call minder, but call minder would have cost you a billion pounds, do you know what I mean, so it is a very narrow scope. It's a different kind of project, so it is large in the sense of its scope not in the sense of the amount of money spent on it.

AC: What you say would be the impetus behind the project, here I have…?

KF: How do you maintain forty percent market share? You have to invent the future, by doing it. We had using this thing, the whole point of concept 2010, was to steal a march on all the competition. To put all of the best ideas that Martlesham had ever got and give our customers a feeling that when they buy our current products that we had got a vision of where they were going. That was what it was about.

AC: What were the original aims and objectives of the project?

KF: Basically that. And to, we needed to find different revenue streams, so you know we were fighting on price, so we needed to fight on added value, not price, so we were looking value added services over the same information, the same data, there were systems whereby on this desk where you could look at a calling line identity of an incoming call to a stock broker and it would immediately pull up from the library, from the database, everything about that customer before you even answered the phone, the other thing is it had systems where, a certain stock went down in value and up on a screen would come everybody who had a shareholding in that one. And the person with the biggest shareholding first and their telephone number would be *being* dialled, the moment you saw it, so you could talk to them and it would give you things to say and not to say. So I mean, they are current products, but that's the sort of value add to the information. Whereas most people are enabling you to program a number, we were going one step further. Well not we, BT was.

AC: Integrating all of those things together.

KF: They were trying to find out the requirements from the dealers. And there were so many different people trying to use this equipment to do completely different things, that we were trying to find out the *key* requirements for the market. I tell you it was an impossible task, because if they tell you what they need to find out they tell you how they make their money, these people aren't about telling you how they make money. So the requirements capture on something like this is bloody nearly impossible. We had to keep putting up ideas, they say O' that's rubbish, O' that's good, they wouldn't tell you why or what they were using it for. It's quite soul destroying. They aren't even, some of them aren't even nice people. A dealer who is making money by having one over on someone else *all day long* didn't come across to me as being somebody I wanted to help make even more money. But that's my problem, not, it was a weird experience to see these people using the kit, frightening. Because, they weren't creating anything, they were manipulating things to make vast sums of money.

AC: Loopholes in the interface even.

KF: Delays, I know something you don't, I'm going to have you on it.

AC: Were the objectives ever formally specified in a document to your memory?

KF: I think they were. There will be something there from the people who came up with the money. The money came from global finance, and I think, there were other areas that it came from.

AC: Did the objectives change over time?

KF: Yes, all the time.

AC: In what ways?

KF: They grew. Initially it was an exhibition piece, then it turned into, well we can do this bit let's sell that and we can't do that bit. And then it became a test bed for trying to put new things in to all the time. It then got to the point where we were actually selling the hardware as well as some of the software. So we sell screens and things that were put together for it, are now products. Somebody even sold somebody some emotional icons.

AC: What did they do with them?

KF: They just play with them, but they sold them, they liked them so they wanted them so we sold them. We attached them to live data feeds, so a terribly simple bouncing icon attached to a live data feed that grew I may have the demo somewhere, run off a spread sheet, it was really crude, its gone much, much, much further than that. I haven't talked about the relationship between us and Syntegra's VR team.

AC: No, think that I do have a question about people working with you.

KF: Coming later.

AC: Have the project objectives been met so far?

KF: Surpassed, if you talk to somebody like Ian Cockburn who was the Syntegra sort of *owner*. It's grown like topsy. You know it started as one thing and its grown and grown and split in two, there's today's desks and 2010 which is tomorrows desk. And its traipses all over the world its even known by our competitors, the project name is known by our competitors and that's quite frightening.

AC: But good also?

KF: Well, they say 'this does it better than 2010', do you see what I mean.

AC: In that sense it is a standard then which is a good.

KF: I don't know if it is a standard.

AC: It must be perceived by somebody to be a milestone.

KF: They perceive it as something that exists and it doesn't really. Because it is growing and moving so quickly, it doesn't really exist.

[break for the telephone]

AC: When did the project originally start, was that '93?

KF: You would have to look in the book, two three years ago.

AC: And what stage would you say the project is now within its time-scales?

KF: I'm out of it, in terms of time-scales its going to go on forever. We spent ages and ages doing data visualisation, information visualisation, VR control systems for it and I handed over the ideas to a unit inside Syntegra, run by Sue Alcock, who drive virtual worlds, initially they were driving Superscape worlds and we found a limit on the Superscape system, so they've transported the ideas into VRML worlds and found they have got the same limits. Which is sad, and they have got some seriously technically aware people so they're taking all of our ideas and doing it for real and her people are adding a lot more to it as well, more customer focused than my original ideas.

AC: Are there examples that they have created at Syntegra that...

KF: Are different yes, they have done three screen systems for visualising the FOOTSIE 100.

AC: Are they three dimensional?

KF: Yes, yes. And they have got lovely ways of running things across surfaces and picking off the detail in a window associated with it. They have lost a bit of the original Oomph to it and it has become another data visualisation and Sue is very aware of that, you have got to talk to her if you get a chance. Or to Dellay and the people working for her.

AC: Right yes, is she based in...?

KF: Fleet, down near Superscape. She is a very bright cookie and she so easily or her team took on board what we were saying and then they just went away and it blossomed, you know, to the point where they had a near term product that they were able to sell. They attached some icons to live data of shares so they bounce up and down and they auto ranged and then they had this activity thing. I will show you, where they when shares become inactive they would drop out of view and all sorts of things, I can show you some.

AC: Is there any contact between the department here and what they are doing?

KF: I am, what's happened was we produced thousands of icons, thousands of ideas and there was only a small channel out through, so there was no point us producing any more.

We found the biggest problem was getting requirements from dealers, Charles Brennan and I went down and talked to an oil trader that we got hold of and it became obvious that Charles was really good at getting hold of requirements in difficult situations, so he has taken over the sponsorship money that I have got this year purely to do more and more requirements capture and if you get Syntegra trying to talk to these dealers they tell them just piss off. If you say you are from the research labs you get about an hour, if you are lucky, we got an hour with this guy. But this guy earns more in a week than I do in a year.

AC: Does he perceive that not to be of value to him at that time or that is a potential threat for him to?

KF: He saw it as everything. While everybody's trading on a level playing field technologically, they can all trade together. If somebody comes in with something that's better, then they've all have got to have it, and therefore there is not any commercial benefit, except for those who, trading isn't about technology, trading is about human greed and the way humans work, and one of the interesting things that shows that is he was very interested in having calling line identity which he hadn't got, BP don't have our system they have somebody else's. And it doesn't give them calling line identity, and I said 'what are you going to do with that', and he said 'well I'm going to know who's going to be calling, before I lift the receiver and therefore there are some people that I can keep waiting and make them drop the price. Yes, I know who it is if I can make him wait another half an hour the price will go down'. And this was the sort of way in which they were using the technology, so its that's sort of requirements capture, it wasn't about greater information about telephony. It was about human aspects and Charles is great at pulling that stuff out.

AC: And he's doing that currently?

KF: He's taken on that project.

AC: Is there a point at which the project will finish?

KF: It is finished for me, it will never finish, it was started because there was a void, there wasn't any future vision of dealing rooms, this is a constantly rolling vision of which we feed, BT labs, feeds in new things and Syntegra do, and our outside suppliers. So if they have got any new tricks, there was a lovely thing in there from somebody which was a video, because it has video telephony on it, Multi-point video conferencing, and it has a camera that follows you, you know, and it was put on the desk and it works. It just gets incorporated.

AC: And there is Charles and you mentioned Sue, are there any other people involved in it that are key people?

KF: Dave Heatley. He runs it, he's the guy on site who runs the concept 2010 money. Right, and the reason he has got on it, is because the major spend on it here is optical cordless desks. Broadband two way communication, cordlessly, to a desk but not using radio, using light, and that was one of the projects which we incorporated into the desk 2010 desk, initially, as a concept and now Dave has built it with an outside company and it has got twin 155 Megabit links.

AC: And it works fine?

KF: They look like a big spotlight in the ceiling, and you can roll desks under them, and backless voids, and it knows which desk is where because each desk has its own identity, and it locks on, and no wires in the floor any more, and you just wheel the desks around. And the desks haven't but could have an optical back plane, so it goes in light and stays light, instead of going in light and turning into electrical cables. It will in the future have an optical back-plane. We've got those already, it's just a case of integrating those two together.

AC: Who was involved in the actual designing and making of the visualisations?

KF: Desk? O' the visualisations, myself and Sue, myself and Dave Knight, Dave Linton, Dave Linton's left, or retired. And this other guy who I can't remember, who worked for Michael Gell - Tony Reader, Tony is a very quiet guy but had a tremendous push on the 3D trading room patent.

AC: And was Sue the only one who was outside of BT?

KF: No outside of, she's inside BT. Outside of BT on the desk there would be loads of people, a company called SBFI, Specialist Business Furniture International, or something like that, they're the people who built the desk, and they build a lot of trading room desks, they built the actual desk itself, Microvitec and Hitachi, another company I think called CCI or something they are a video conferencing company, they were involved, all sorts of people, Digital provided the computers free.

AC: And in relation to the visualisation aspects was anything outside on that?

KF: No, just Sue and Sue's team, Dave, he was the real number cruncher who really knew how to tie live data into a virtual model which is what made it really work on the desk. Live share prices coming driving live objects.

AC: And in relation to the project, I have got one folder on it, I have seen the video and I have a copy of the video, which was the one where the trader comes in and the scenario is built. Is there any other information on the internet about it?

KF: Probably, I don't input to it. I would imagine there's something if you searched under concept 2010 you will find it.

AC: Within BT or generally?

KF: Well it will find out Syntegra and everything.

AC: Is there anything else on video other than the pieces I've got?

KF: You would have to ask Ian Cockburn who owns it all at Syntegra: He may have some more video footage. The thing is there was a desk here, I think, Dave Heatley's got one, there are only two or three in the world and we've got one here.

AC: You have some demos here, are there any other demos anywhere else?

KF: My demos would be duplicated on the desk, plus Sue Alcock's team's demos will be on the desk.

AC: Do you have any of Sue's demos?

KF: Only the one that is a modified version of mine. The others work in VRML and they have to be attached to live data you see, coming in and I don't have the OTS, the open trading system, feed is an ISDN line in to the back of a PC and it is attached to something we charge 'X' a month, right, like this is live share data, live mega data, and we charge a 'X' amount of money for this, because we take in Reuters, we take in Nightridder, Dow Jones, we process it and put it together and then sent it out OTS and the other thing is if you go in there you are attached to what could be a live trading system, so we have to have pass wording. So you have to be a bit careful what that is that's real, attached to the trading system. I don't have that to my desk so I can't run those demos.

AC: And is there any information that you know that has gone through perhaps conferences or newspaper clippings kind of external?

KF: There are, Dave Heatley would be the best person to get that and Ian Cockburn. I myself have not published anything, I think I have been included, because the desk is so broad and my part of it is a small part. It may be published all over the place.

AC: Do you know of any television programmes or broadcasting?

KF: Yes I've got on my show-reel there's a couple of things on there, Channel four, Equinox, things like that show bits of it. It gets used in somebody's title sequence.

AC: Do they use mainly the desk bit or do they use the visualisation?

KF: Well the screens are dead without the visualisation and my visualisation doesn't run all the time in the demo it sort of runs in the background.

AC: In relation to the actual interface part, just the 3D parts, the purpose of the interface would be to visualise the data is that right?

KF: Well first of all the desk currently, you are going to say that I dropped out of this about nine months ago, I was still involved but actually changing the demos up to about

nine months ago, what we found we got four screens three in a row like that and one flat one down there.
And on those three screens here this flat one was converted into a touch panel, the three screens we had got eleven windows running at any one time. Right, so they were really difficult to do and what we envisaged was a stretched version of this, so if you were to, we actually took this. [Talk to me talk to me], right, we stretched this visualisation here, over three windows, right, and we had the idea of one sort of set of topics going on here and another set of topics going on here, another set of topics going on there. Instead of eleven separate windows you could actually sort of click on something and go to it. Right, so this would be your user interface to the world but across three screens, that's how the concept was. So this was a way of navigating between all your different systems instead of navigating through lots of windows some layered over others. So that was the basic concept behind the desk but it had to be split basically like that across three windows. So that was our basic thing, the proposition that you would sell. And you would fly into the data space and they wrap round you these windows so you actually got a feeling of going into some thing, that was the initial navigation. I've explained navigate to you before, haven't I, as a world, all the different things in here?

AC: Yes, I mean if you want to go through that, shall we zoom in on the camera so that we can see the screen?

KF: If we go back here, what we were looking at here then was, if we go through the demo I would have done. We have got shared spaces here, so you could see who you were working with who was looking at what pieces of information. [Reset], we could have your standard, this has got click on and fly to which was one of the things we patented. This has got the ability to look at your normal 2D screens if you wanted to, in the virtual world *live* inside the world, this isn't but we could have a live version of that, so your old screen could run inside the world. And we had the ability to jump from here to other places, so in here, I think if we go, that one, yes, we can go to, this is an idea that this is one deal, this is another world this, and then there would be another deal being set up over here, so you have a concept of deals in a world rather than as windows the actual information was there. So in this case we could, these are much more complicated than just that, these icons in this world that you are trading in, do you want the whole bang shooter? OK, the concept behind this was they weren't created by you as a user they were created by Citibank or Natwest and given to you, like virtual portals into their own organisation, supported by them not by you. So when you want to make an e-mail, right, and you want to send it to Kim fisher in BT, what you did was you got the e-mail and you dragged it and stuffed it in there and the moment it hit BT it would look at the top find it was for Kim Fisher and route it using BT's system for finding Kim Fisher not by me as an operator maintaining where Kim is going to be, do you see what I mean? So that was going inside a sort of pass-worded safe way into city bank and then off you would go. And these you could pull together as you were forming a deal or something. So you got the geographic feel of a deal, you could even proportion these such that they were relative to their importance or ease of use. You know, I'm always going to see, this is a particular bank, and they know that cherry tree and so for the banking community everybody knows who that company is and I can't for the life of me think who it is now. But you see you could click onto any of these, and get around yes, and then you could go inside them, in this case we could not only, 'welcome to Citicorp's world wide web server', so you could have it clicking in that case to a world wide web server and jump from there into Citicorp's trading room, and this is then where the patents started, right from, this is one of the demos inside 2010. Do you want to go into that? Right.

KF: The idea that Michael Gell had and Tony Reader who worked for him really I think had the idea, was to use a video projector, to project onto a screen sort of in the middle here, of a trading room so that all the information about trades could be shown on this screen, to draw this for the patent he came to me to see if I could draw it. And rather than draw it I made a virtual reality model of it because to animate it was easier, then from that we realised that we had created a virtual reality trading room, right, rather than a virtual reality model of a real projected trading room, so we patented that and that's caused a bit of a stir really because this allows you to join virtually with disparate traders, not necessarily to trade, but maybe as watching what's going on, you can see that there is a trade from there to there, that colour meaning something, the size the direction, yes, and somebody can ask you for trades, so in this using click on and fly to you can set up a link, 'I'm David I want 14K BT unpaid'. Right, yes, do you understand what it is? This can have different ways here's Matt getting animated, attracting your attention they could be live video windows in the virtual world, they can be different ones, infinite amount of them in the same world. Ask Dave Linton who did the programming. He has taken all the times.

KF: The beauty of this system was in Windows you would normally have one window for video telephony one for data visualisation one for Reuters one for, do you know, windows galore. And what we were looking at here was that you could have multiple objects in a world, so you could still have your 2D you can have your video telephony, your data visualisation, and if this is the right one, down here was actually live shares of your own portfolio you know, like your own BT and Halifax shares could be bubbling around here and only shout when they went through a threshold or whatever. So what we were able to do in one visualisation was all of these different things which in windows 2D would be various windows. They're all inside one world, wrapped around you, so you got the feeling of being in it. Like you have a feeling of being at your desk with all your equipment around you.

AC: So using space to prioritise things?

KF: And audio. This isn't doing it well but we could have something busy going on out of your sight, that had no warning, flashing or anything but you could hear that something out of screen was happening like shares were going mad somewhere. So you could swing round and look for it, you know over here and that was, gave you, the audio gave you as much feel as wrapping the visual around you, in fact it gave you more feel.

AC: The audio is three sixty the visual is only…?

KF: What ten, twenty degrees, thirty degrees depending how close, with our spread screen ninety degrees maybe. Do you want to have a look at, I will try and fire up the other one, I have never done it on this machine, so it's a bit tricky, what you have to do is fire up excel, you then get a spreadsheet running, this is '97 so it may not work, it's a bit dangerous to do this. We have moved all the files around. It might be in here, no.

KF: So there's all the shares and then this, what's happened here? [Here we are, there's a thing called auto, gosh, user, auto, right, shrink that down, shrink that down], there you are the shares are now bumping up and down relative to the values changing on that spreadsheet. So we could normally feed in values live then to icons on the spreadsheet, yes, and then, when they have become inactive for a certain amount of time they drop down out of the way and then only the ones that are in your thresh-hold of interest remain up there, so bits and pieces, and we had see them changing every so often. There you are one jumps up, what's, the actual demo that finally appeared in the trading world they had red green and blue, green staying still, blue was it blue staying still green going down, red going up or visa versa, whatever it was, and we also turned them into pointy triangles, pyramids, so that you could see that maybe above your average for the day but that it was going down at the time, so the triangles, the pyramids were shaped and if some went out of speck out of your limits, they would start shaking as well, you know wobble, wobble and they were attached to live currency across here, and they had the flags of the nations relative to say the pound or relative to the dollar, right, yes and what happened with this, this was live data, see it all bouncing up and down, these then, if you look at them from the side, every time they changed, they would move forward one, so they, so that if you looked at the side of the graph instead of this just going up and down you would see the history over time, can you see that once we got that to do that we had got a VR world going up and down live to real, you know, real figures.

AC: Was that a very difficult thing to do?

KF: It was to do the very first one, to attach this data to the very first thing, then we used the open trading system when you had on the open trading in windows we had the fact that you could highlight a figure which was a live feed and you could paste it into any other window so you could actually take a live feed and paste it into a spreadsheet and instead of there being a figure being in the spreadsheet that you put in, it was an OTS and open trading system, it was a live data feed. Once we did that to the spreadsheet that is behind here we had all of them going up and down relative to live feeds and then we got other cells formed which was you know the history, so when this one changed it copied the thing to another cell and it drove another one, and we got to...Then we got a surface, made out of different cells, of columns going up and down so that we got like waves forming over time of trading you could see like waves of trading like wind across a cornfield, is what we called it and then the system ground to a halt because it was rendering hundreds of squares and having to change them every frame. So what we did was we got rid of the, well Sue Alcock's mob got rid of, the object and turned it into a facet, single facet on a surface. And did it in VRML and we then got this waving surface like a, if you imagine a flag in the wind, its straight at the front, waves out behind, what you got was this flag moving through space constantly with all the share prices changing and then what they did was they had the ability to point at a position on the flag and it would give in another window all the data of that point, so you could mine, by just moving your cursor across the surface of the, and that's what they can do now, from it.

KF: The other thing they did was, have you heard of Chinese candle sticks? As a method of data, so you put the top and bottom of a range like that and then you have a block which moves up and down the, to show where you are in that week's trading range, so they turned each of these instead of wobbling things they turned them into a candle stick with a block sitting where you were, and they turned this into three layers; so there was effectual, ineffectual and forget it, you know, sort of thing, so that this was just purring away. But, that was a real eureka moment, when we attached the first bit of OTS into that spreadsheet and substituted this stuff. That was a real, I can remember it, there were about five or six of us around a desk up in and we got one icon go up and down relative to a real share price coming in, and from that moment they haven't looked back really, and I let go. That's one of the demos which was a killer and they've done lots more detail with it, I'm not sure I have got, got their final detail version, there's nothing else there, no. I haven't kept up with that because you had to have the latest browser the latest this, the latest that, for it to work and I was working on old stuff, no. OK, do you want to, we can zoom back out.
Those were mainly the demos that were being used. Yes OK?

AC: OK, so ...

KF: The ones that we used, the demos that we used on the desk were emotional icons, navigate, which is the flying around the world with the magic carpet and the click on and fly to, then we jumped to that Citibank and all the other banks World, and then we went to the trading floor, the round trading floor, and then we went from that if we'd got it, to the live data feed or the spreadsheet version. But a much more sophisticated one than that. Like I only did the building block and I got out of the way at that point.

AC: Right, I had envisaged that there would be, the thing that you have been describing, the wave and things, that you would have a copy of that.

KF: It's available I think maybe, I don't have the. They gave me various versions of it, right, but they all depended on being attached to an OTS feed. They didn't have a spreadsheet version because there was no point for them, wherever they demoed it they could have an OTS feed. I haven't got a system OTS feed, so I haven't got any way of demonstrating it. It just looks like a flat surface unless you put live data into it.

AC: Do you think that the navigate part is, what date was that aspect of it?

KF: Three years ago at least.

AC: Do you think it is worth me contacting Sue, and having a look at it with her the current version that she has?

KF: Yes, She didn't do the navigate part, they have done a lot more we have got minutes of all the meetings, you have. And her people have got lots more demos but what's funny is they used bits of mine, in, because I was sort of a catalyst you can get her opinion of me, of my work and Dave's work, we did do some other ones. I'm just thinking actually, whether I have got them here, is it worth having another hunt? I'm trying to think what we called it, Dave Knight, we did some surface ideas. I'm trying to think where it would have gone.

KF: I was trying to, this year, get them interested in concept of, that surfaces that I was talking about, ah, here we are, islands, yes, here we are, spherical cup, Kim's shape. Let's try that.

KF: What I was trying to do, was if you can imagine I've got this idea not everybody buys into, is that you've got data put together and you get information, when you get loads of information you can gain knowledge from it. If you want to hear the converse argument of that, talk to Charles, because he doesn't agree. Here we are, here's a thing that Dave did for me, now what I was trying to do, was, this was built by Dave Knight, I reckoned that we could visualise data 'til the cows come home and you wouldn't gain any more than an experienced user could get from figures, it's only the inexperienced user that could gain more. The people who are the customers in the dealing desk are *not* inexperienced people. So data visualising shares bouncing up and down meant bugger all to them. They could see that anyway after ten years of looking at the screen. What they needed was information visualisation, but really for the information they only needed was an access system, so they really needed navigate for information. What I was trying to do was visualise *knowledge*, right, now what the hell does that mean, there are various viewpoints here, lets see if Dave's set up the viewpoints, yes, what I was trying to do, I'm not sure this was a really good version that I have got, what I was trying to do was to try and create shapes from totally disparate objects, so if you could imagine what I was trying to do was to take a surface like this and here's a whole load of points, Dave turned them into a petals but. And that was a flat surface and attach to it some kind of object that would distort the shape, a control in this case, and you click on it and it would distort the shape, yes, and those controls could be anything, like a share price, the number of times a commentator mentioned on television BT, all this sort of weird information you could mine, like you know, what I was going to try to do was we could track every thing that was going on, on a trading desk up to a successful deal, right, wind back everything that was happening on the desk, both audio, video, people around it, wind that all back and see which aspects of it were becoming common, to a successful deal, across deals, what was the successful combination of events that created a good deal, right, because I don't think it is data, its something else. These dealers are doing something else. And the circumstances they seem to feel as well, from one or two that we have talked to, is the combination of human things, right, like this guy always phones on a Thursday night and I know he has got a problem if he phones on a Thursday night so it's a good deal for me. You know, or this boat is just about to dock, this oil boat and he hasn't got somewhere to put the oil, and I know that, so the longer I leave him worrying as this boat gets closer and closer to the dock and he hasn't got anywhere to put the oil, I can get it cheaper and cheaper and cheaper, right.

KF: They are not raw data they are knowledge and what we were trying to do, this was the work I wanted to do this year but it was too obscure really, was to say we would visualise a deal as a shape. There's a surface, attached to it would be the number of times BT appeared in a conversation every hour, the position of this particular boat relative to its dock, the number of times my girlfriend has phoned this week, you know, how many times a dog barks, all sorts of weird things which have been boiled out of what was a good deal once twice three times and four and attach them to a surface. They would then distort that surface and there would be a shape that was the shape of a good deal. Right, understand what I was trying to, then you could have all of your deals sitting around you attached to these parameters and you would get to know a good shape forming, right, that was the deal, now Dave tried to show it by petals attached to a flower.

AC: It's like a formula one telemetry or something like that, so you could actually go back over a period of time.

KF: Exactly the same, but not just data, some of these things were human things, not, I always do a good deal after I've come back from the pub and six pints, but it could record that, do you know what I mean, it was ever so easy to record automatically. Been away, and on there some of the traders they have to say were they are going, what they have done.

And it was just trying to roll back make them parameters for future deals and then have the deals modelled so that you started to get the shape of a deal form. And it was also, you know, it feels like a, or it looks like a good deal or it has got the feel of a good deal or, do you know, they talk like that, and I was trying to model this. I think there was a much better version of this that Dave's got some where which he spent ages getting. This one is called shapes, lets try this one, *wow* wrong one, this was where I was, we were… Does this make sense?

AC: Yes, yes total sense.

KF: O' it does. Let me shut the other one down, we've got problems, we've got two programmes trying to use the same. I'll have to undo that. We also wanted to try and put together the idea of, rip off the idea of an information islands, yes, you know the information islands?

AC: I haven't seen the information gardens but, I have heard of it.

KF: This was Andy McGrath's work.

AC: This exact world?

KF: No, no, no, this was a rip off; Andy's was far more sophisticated. What I was trying to do was to make environments for things to happen, so certain information would live on certain islands like Andy's stuff, and then tie that into, if you want to do a certain type of work or go and see a certain type of information, you actually go to an environment, and in that environment it would have information islands. And it also ties in with some knowledge management work and things like that, that was another thing.

AC: How do you associate the landscape features to the information, or does it not?

KF: If you listen to a dealer, they talk about the geography of the deal and what I was trying to do was to try and generate a real, if you call a virtual world, a real geography from the way that they talked about deals, you know, like I can see this one coming at me, or like this one has hit a barrier. If you listen to the language of the deal, they think of it very physically as an object or as something going on, or this deal met that deal and I got done or something or wiped out. And It's almost like the deals were physical things and we were trying to model them, this is getting really a bit woolly, but...

AC: It makes a lot of sense, though.

KF: It made a lot of sense, but not to the dealers.

AC: Until presumably you visualise it and then it does.

KF: Well, and then you had done it, the thing that worried them about it when you said I could visualise it, was I'm not going to tell you the parameters I use to judge is a good deal or not. Because that's how they make their money, this was an idea that...

AC: Unless of course you give them building blocks and then they use it.

KF: That's what emotional icons was, wasn't it. This was where we were trying to say that the world was not inanimate and we were trying to get a virtual world, he hasn't done it yet, there are better ones, where you could mix the live data with the geography, yes, yes, so a deal, you know some piece of fact would come in, and sort of roll around, it didn't have to come in and smack you in the face, and take over everything, you know how when the phone rings that's it, it just takes over and it's totally out of proportion to what may be on the other end of that phone. And one of the problems with information is that irrespective of its content, if it is delivered electronically, it is all equally sent to you.

AC: Its either yes or no, its digital its either there or it's not there.

KF: Not only that, but the content of it, whether it's a junk e-mail about going to the pub tonight or whether its you've been fired, the e-mail comes up exactly the same it doesn't know anything about its content. And we were trying to get information sorted and, from content, then added to your context, and therefore, this thing would come spinning around in your social bucket, 'O' there's something there'. Something else, and it would be done from content, and if it was O' my god, you know, somebody's blown up Fort Knox, or something and the whole bloody thing would take over the screen, sod anything else this is really, really important to you and that was stitched in with some of the agents work.

AC: Presumably, if your context had a certain relevance if your world was quite still then something quite small would be quite noticeable, whereas if your world was chaotic small things would disappear.

KF: That's taking it further than we had, but they were ideas, they have not been taken any further this year, because we have got more ideas than any channel to develop them, yes, you keep forgetting them don't you unless you dump them into a little world like this, its like a notepad, a virtual notepad of ideas. And then you have only got to see the thing, 'Ah I remember why we did that'. We haven't taken it anywhere, but that's what sells our future view to our customers, when you can talk like that to them about visualising. They had never thought of, that they actually talk about a deal geographically or physically. And if you could just interpret that, it might, it won't necessarily help the dealers but it might help their bosses to understand what the dealers are doing. Which worries them.

KF: Right, sorry, we are wittering on.

AC: How much time have you got?

KF: Well I don't want to do a seven.

AC: And we will apply the questions that we have done previously to that. Because I think that out of the ones that we have seen just now that one is the most complex in the sense that it is the most developed. And it will have aspects that have relevance to the questions.

AC: When this one was created was there a brief for it?

KF: No, no, it was way beyond concept 2010 it was a long time ago, Rob Taylor-Hendry and I and Paul Bennet were down in an office down here and we had got future services and concepts or something to work on, which had at that time generated the future desk, it became very clear that a desk with lots and lots of features on and lots and lots of access to information, would be very difficult to control if you had Windows as your user interface.

And we had also, I had also come up with the idea of emotional icons. And it was Rob who really talks about 'the problem here isn't visualising data, the problem was getting around it'. Long before people started writing papers on data navigation. That's what he was talking about, and the whole of us down there after a few pints.

KF: Ah there's the man, Dave Linton. The man who wrote the stuff, were just talking about navigate click on and fly to and everything like that.
Do you know Andrea?

[break in conversation to talk to Dave Linton]

KF: Right, yes so there was click on and fly to and that is the guy who wrote the code.

AC: I just thought that you could do that, I didn't realise that it had been written.

KF: We patented it, people can do it now but not that way, if you look at this and tilt down, there's a subtlety to it, so its up there, you watch, it swings you up and then takes you on the path and we found that a lot of systems you click on and it just takes your view and just slams you into it. Even though you are looking over there, you were still looking over there when you hit it, and there wasn't anything human about it. So what Dave did was he got it such that your viewpoint turned to the object in the centre and that kept you stable while you did that and then it accelerated you to it, to get there quickly and then slowed you up, so you didn't smash into it and that's made an awful lot of difference to the usability of it.

AC: These tiny subtle details that make big differences.

KF: It made it feel logical, it made it feel as if you were moving. Whereas some of these things made you feel as if you were sliding sideways on a piece of ice. And you were slamming into things and it wasn't nice to use, so that's what he did and he did it with some very simple maths, about four lines of maths. Rather than anything sophisticated so that you could apply it to any object, at any distance, from any angle. That's what made a good thing about it and he designed the magic carpet and the holes, things.

AC: Well OK. What software tools were used to create this?

KF: Purely Superscape.

AC: What release would this have been at that stage?

KF: About 3.5 to four.

AC: And at that time did it express the state-of-the-art for the software?

KF: Yes, we have always fortunately had state-of-the-art.

AC: And since then have there been any huge changes in the software?

KF: Yes, the renderer, but its not, and it has gone onto '95 so its slowed down, initially we were working inside DOS. What happened was that the speed has stayed the same for the last five years. It's just the software has had to deal with terrible operating systems, like DOS it was really fast, and then it went windows 3.1 and it got really slow and then the processor speed increases to bring you back to DOS performance, then it hit '95 so the processor dived again, and now the processor speed has gone up and we are back to the speed of. You run this in DOS and you see the difference, even if you run it under a DOS prompt, we can take that right, right, how slow that is and if we open that up inside the DOS visualiser, I'm not sure I've got a DOS visualiser. But, still on here, but it would go like that, it was ever so quick, because it was not doing all this windows rubbish, every frame. Not looking for multi-tasking and things like that.

AC: OK, and what was the justification for using this software for this particular project at that time?

KF: Because designers could drive it, when we needed serious bits of coding we could get people like Dave to do it because it is in pseudo C, but they used to complain bitterly because it wasn't proper C.

AC: And does the software represent the ideal choice for this particular kind of interface?

KF: The only choice, at that, O' at that time. There's probably half a dozen ways of doing it now.

There were three pieces of software you could use when we started this, they were called world toolkit, which was a terrible user interface for a non-techie, there was Superscape and there was something called photoVR which was a PC early version of something a bit like doom / QuickTime VR. Gary Dalton did a lot of work on that but he had to have a full time programmer and that was about two or three years earlier.

AC: Right, and do you think in this case the software you were using constrained creativity?

KF: It did both, it constrained what we could do and it gave us things we didn't know.

AC: In what ways? What examples would there be?

KF: Gravity was already built in. So all of a sudden things could fall and drop and bounce and we could add those to our own functionality that we hadn't thought of adding in the first place. So it gave us features, sound, attached to, stereo sound attached to objects. You know things we hadn't...

AC: They were positive benefits.

KF: O yes,

AC: Were there any things that you felt held you back from the things you wanted to do but the software couldn't do?

KF: Textures, in the early days it was very difficult to add what we call textures which are graphics to surfaces. We wanted to run live graphics, you know, MPEG surfaces and we couldn't, we can now, its not a problem, it just eats processor, bandwidth.

AC: Was the service ever intended to be delivered over a particular hardware?

KF: It was, no, O' that's a lie, yes PC.

AC: And would that be different from the thing that made the...

KF: No it would be the same, exactly the same platform, what I thought you meant was did we envisage it as going out as a sort of turnkey finished product, this was always a researchy thing from which people like Syntegra, Sue Alcock's mob, would actually turn something real out of it. We would keep firing ideas into it.

AC: So we have seen quite a few different ones, haven't we, this one, would you say that this is err...

KF: Plan views, I just thought I would change the view.

AC: Do you think that this would, well have a look at the list, which of these things do you think this particular interface excels at?

KF: It challenged a lot of conventions.

AC: In what ways?

KF: In the sense that we were suggesting that you used a three dimensional world to hold all your information, access in to your information, and not only would the world, it was a bit like a folder on which you could read all the contents on the front of it, whereas at the moment you have to open a folder and then open Microsoft Word and read the contents of the folder in Microsoft Word. Right, what we were suggesting is that not only would the navigation of the information be a single world but the objects could play within that world as well, which is a very different concept form the current desktop metaphor. One is a filing system and then the other is a program operating system. And you take the files from one and you put them in the programs of another, we were throwing all that away. And we were trying to say that as you walked up to a document it would be open, you never opened it in a program or found it. That was a document and it sat there.

AC: So the two were combined the actual thing that made it work and the thing itself?

KF: Throw away any difference, it was a document, you saw it as a document. It's a bit like my analogy for this radio clock, the only reason clocks currently have an up and down minutes is because you have got to set them. Once you have a radio signal clock that listens to a time signal, you don't need any up and down controls, you just put a battery in it and it sets itself to the clock, and I think it is that analogy with your information, when you looked at a file and clicked on it and went to it, it was a document. You didn't open Word to look at it.

AC: I suppose the halfway house like Mac any way that you can click on a file and it will open the document for you.

KF: Yes, but you have put the concept that it is opening a program. And what's happening nowadays I believe is that Microsoft Word has now become more difficult to do than what you are trying to do in it. You weren't trying to learn Microsoft Word what you were trying to do was write a report. Now the tool has become the task, not the, yes and that's wrong. I think that the way forward is for us to go back to basics, and you know, a word is a word is a, a document is a document is a document or a video picture is a video picture is a video picture and you don't have to got through a mass of stuff to get hold of it, and have tremendous knowledge in some cases just to open a ruddy memo.

AC: I think that with, when I teach the students it takes them two years to learn the software and then they can, then it stops being a barrier to producing things.

KF: There are some benefits, like Japanese have 26,000 characters and they can read ten times faster than we can. But, you have got to have spent many, many years knowing the 26,000 characters but once you do, you can do things with it quicker. I think that there is no need for the characters if you can give them a video, or make it clearer or a model they understand intuitively, I don't know, there's a bit of everything.

AC: Would you describe this as navigate, is that how you would characterise this?

KF: That's what we called it, because we realised that it wasn't visualising the data it was navigating the data, so this world we had, this was a crib of one that Superscape have, but what we did was we started adding, they have cubes and circles with little flashy lines that's all their thing, what we added was things like click on and fly to, so you could see a whole network of either information or companies or whatever; the speed at which it flew to it could give you some idea of how big the content was. This one I have shown before haven't I? Where it is a virtual lift, so you go to BT and then you go inside it, this is all very slow bearing in mind that this is a dog of a machine. And when you're inside you are in like virtual lift buttons, I don't think that the metaphor works terribly well, but you can still see where you were from within it. You would if I didn't keep flying through them, if we just shrink the window a bit. We'll find the speed at which it renders is much quicker, there we are, you can see out but you are in a place where you can press buttons.

AC: In the IBM the real spaces they have a hot air balloon to take you from floor to floor.

KF: Yes, yes, I mean we were talking about that IBM because I thought it was quite good and not me just sour grapes or not designed here syndrome. It's a bit like that metaphor having a chair in a virtual world I mean it's absolutely pointless because you can't sit on it. And unless you are going to buy that chair there is no point in seeing it. Some of the things we were doing here, we <u>tried to throw away, you know like minimalist in a virtual world I don't need a chair I didn't really need a lift we were trying to leave the attributes of a lift but not it's artefacts.</u> So it doesn't have doors.

AC: So something reaches perfection when you can't take anything else away but you still understand what it is?

KF: That's somebody's, who's was that?

AC: I'm not sure actually?

KF: Drayer or one of the Bauhaus guys, wasn't it, gosh, that's going back to college, I can't remember. But I believe in that, to a certain extent, as long as it feels nice.

AC: Ok, so in here we have is there two dimensional because it's mainly a three dimensional world but you have two dimensional aspects?

KF: I would like to be able to mix them all audio, 2D, 3D, movement. There's a difference between movement and position.

AC: Right in what sense?

KF: Movement can give you a sequence of events, position can make you relative to something else. So if something close up to you could be more important, is perceived to be more important to you currently. You have got to imagine that some of this world could be actively driven by real information, is what we were talking about, like the icons, the position of objects in here could change, they can come closer if an intelligent agent set up by you, thought it was of importance to you. So there will be fixed geography like, you know, a normal roads but the contents sits at the side of the road, the crowds would change, do you know what I mean? You need geography to find your way around, you needed, the crowds would be a transient thing. So you don't want to move landmarks around, else you get lost. But certainly you could build crowds around a landmark like that will always be in the same place but the number of people around it and the noise coming from it would change.

2D always remained in 2D, in the sense that you don't perspectivise it, you get real problems.

AC: Right and the numerical information is on there as well, but was it obvious when it should be 2D and when it should be 3D?

KF: I wasn't going to prescribe that, that would be prescribed by the user, whatever they were best at operating.

AC: And in this sense all of those types of representation exist within the 3D, but then ultimately on a 2D desktop, but really they are within a completely 3D world in this.

KF: When you wrap it on that big screen on concept 2010 desk, and you sit down there, you talk to the guys who demo it, for days on end in Washington. They get in it, they're in it rather than watching it. And that's the difference I think if you've got the visualisation right, they are in it, rather than watching it, they know that something is happening behind their head from the audio. They can here the audio that something is happening here so they spin the object round, the viewpoint round and there it appears on the screen, do you see what I mean, now that is the kind of perception that you can't get from windows 3.1 or 95 is it. You really can understand things outside the screen on that, and that I think is a real plus point, and this is easier to drive than Windows, you know, processor wise it eats less. The actual programme that is running this is 1Meg you need 16Megs to run Word.

AC: In this particular interface can users change the information which is displayed to them?

KF: In my demo no, what we were perceived to do with it, Sue Alcock's, yes, so mine is fixed static information, the moment you start attaching it to a live data and you give it to a customer who can then put this somewhere. Then Sue's stuff, yes, they can change the viewpoint they look at objects and I think they can import new bits of data and get them to form new surfaces, do you see what I, or influence the surface differently. I'm not sure what state they got it to, I think they got it pretty sophisticated its almost doing that funny shape thing that I talked about, you know, add this live data with that and that and you get this surface so you know what a good deal looks like, I think they are almost getting to that.

AC: And how interactive would you say that this interface is?

KF: Its interactive in the sense that nothing in it is pre-programmed, in the sense, no, you can go wander anywhere you like and the objects will react in pre-programmed ways but only when you activate them, some of them, only when you activate them. But it is envisaged that all of them would be autonomous. Because they would be attached to live information.

AC: Has the interface ever been immersive?

KF: I have tried it once on a helmet.

AC: It was never envisaged as that?

KF: No.

AC: How did that change it?

KF: I just thought that the rendering was rubbish. Yes, it didn't add anything.

AC: Not make you feel more immersed in it or anything, more of a presence?

KF: I got more turned off by the size of the polygons you know each pixel was about the size of a golf ball when I stuck it over my head, each pixel looked so big. Whereas looking at it in this context it is like looking down a slit out of a bunker, isn't it, its got more perspective, rather than being hard up against your eyes. I'm not saying that you couldn't do that now, but, not many people want to spend their working life with their head in a bucket.

AC: So within the space does the user have free movement?

KF: Yes, with some limits.

AC: In the 2D and 3D...?

KF: Yes, I have turned off YAW, you know, that most VR worlds have YAW turned off, because people can spin and flip themselves.

AC: When might you want it on?

KF: If you are doing a flight simulator.

AC: And that is about it really?

KF: I don't know, that's the only one I know of, I'd imagine there are other circumstances, if you want to spin spirally down a molecule of DNA you would be a bit funny doing it, it would feel a bit like going down a helter skelta wouldn't it, looking out the sides all the time, you might want to tilt and go with the flow, in which case you would need a bit of YAW to turn you, I don't know what other.

AC: Like a racing car game?

KF: Yes, something like that.

AC: Are there multiple vantage points then in the space?

KF: Yes.

AC: Can you as an individual be in many places at once?

KF: We didn't configure it so but we could be. The thing about viewpoint flying on this software is you can only fly the viewpoint in one of the views, you can have multiple views on a screen, but you can only fly the viewpoint in one of them at any time, so I could have eight windows but I could only be moving the viewpoint in one the others would be fixed. But if I was perceived as being an object, like the viewpoint is an object in this world. You understand that? There is a thing called eye an eyeball, I could fly around this one view here and there would be a view over here showing me flying through it.

AC: So you could see yourself.

KF: Yes, emotional icons one when you go to that view point you can see the eye moving around the icons jumping up and down on the checkerboard, that's where the viewpoint, one viewpoint has become an object, and you have a fixed viewpoint looking at a movable one. Yes, you could have some really weird out of body experiences, I suppose, if you start doing too many of those.

AC: Were there any fixed paths in it?

KF: Yes, there's the, I think I have got one here somewhere, it wasn't set by me, there we are, they're great when you put them on the, its just set up by Superscape when they built this original world. The fact that some of my objects were on the path, a path was very, very easy to form, yes its easy to see it isn't it. They're very impressive, yes, this is just so that people get a feeling of where they are. I think they get a better feeling from that and a higher view than they do from actually sort of wandering around on the ground. Do you get a better feel of wandering around a town or seeing a map of it?

AC: Yes, yes

KF: It's difficult.

AC: It's linking things together.

KF: Link the two together, yes, it might be nice to have a little map, I've seen some VR versions of this where they have got 2D and 3D working together, there's a very good game, that I've got on the PC it was done by a, its called Outlaws. Ten ninety nine job, and they had a very good thing there where most people have a map and move the person, around the, when you're moving, what they did which was really clever was to kept the person in the same place and moved the map. Bit like James Bond did in his car in Russia with Love or something. And I hadn't realised how much easier it is to leave the person stationary and when they turn the map turns with it and then the 3D world turns as well. How much easier it was to find your way around then rather than having a fixed 2D map and moving and turning the person on it.

AC: Trying to translate that...

KF: Back to what you saw. Because translating the map turning relative to the 3D world turn, and when I found out how they did it, it was so easy they just took a plan view of what was happening in the 3D world and took the tops of all the objects and just had a yellow line on them. They gave you a yellow map automatically, so it was just another view on the same world, so they hadn't had to write a map programme at all they just took a plan view all the time it was ever so simple thing to do, yes, no that's not something we have done, but. One of those things you find out.

AC: With this interface is it space mouse driven this particular one?

KF: It was originally, you can nowadays add the move bar, which wasn't available when the interface was originally done, and there is also this other way of navigating, which has been disconnected, using a space bar there, but you can have a move bar. I was hoping to navigate around by clicking on and flying to and there's a button, that I'm not sure if it works here, this was the opposite of click on and fly to which is go back to where I have just been, we never did get that perfected, Dave retired. But he says it's a doddle to do and that would be very useful. So, we had this concept of virtual string through a world, so as you went through things like in the old command line days of computers, you could always roll back through your commands backwards and forwards. You ought to be able to do this in a world, you could undo and undo and undo. But in this case you undo a movement, so I have clicked 'O' I don't want to go there' so you are going like this, clicked on this, wooow undo and come back and that's what we were trying to do, it wasn't easy to do, you had to store all of your previous positions.

AC: Is that quite memory intensive?

KF: Yes, you start getting a bigger file than the world itself.

AC: How might actually the mode of interacting with the information be considered, is it hierarchical mode?

KF: No, it is totally individual objects that worked autonomously, is that by themselves, the only thing that worked in a prescribed way, was, no that's not true, there were things that worked in a prescribed way like jump on the magic carpet and it went a fixed route. Go through one of the squares, there's a square over here, right if you click on that square, see how it turns the viewpoint, centres you, when you go through that loop it will always take you to the next loop. If you go the other way through that loop it will always take you back to the previous one.

KF: This was part and parcel of the concept of <u>object orientated programming</u> in a virtual world, that's getting a little bit heavy here, but we had the idea that you could do things in this world, if you imagine this little path here, with data coming down to an object, that's data pouring into the world. We had the concept that you could go through, you could do something so, down would come a picture in full colour, and the first thing you would do to that picture would be turn it into black and white, and then the next thing you would do was save it as a bitmap, and then the third thing was you would rename it with an 'a' suffix and then print it, right, that was your sequence, and you wanted to do that hundreds of times, so in a normal computer you would have to do it hundreds of times or write a routine, which for most users like me is not possible, but if in this case you could drop off, like a pebble from Hansel and Gretel in the world, after you had done each item, we had them envisaged these are pebbles with stones in, with holes in, it knew that when you went through that it did that operation, yes, if you went through it the other way you would undo that operation, that was the concept of this pebble, you would then drop them off at various stages during or going through a world, right, and that would allow you to programme, set a programme, you have now got a set of loops, right, that did certain things automatically just by dropping them off creating them, they would have a code attached to them. We then got the idea, that there was gravity in this world, and you wanted to do it to a particular stream of information the same thing repeatedly, you would stack the loops together, turn them on their side and push them underneath where the data came in, yes, so all of a sudden they would come in from the top, using gravity as an object, a photograph, a colour photograph and by the time they popped out the bottom they would be stored turned into a bitmap with the name with a suffix 'a'. And you never had to do it again, just by dropping these things off during the world, and that was object orientated programming in a virtual world.

AC: Right, Is this something that is widely done now or?

KF: No, no. Lots of people object orientated programming, lots of people doing virtual worlds, one or two doing one in, for the other but not inside the other, do you know what I mean, I think there's people creating worlds by object orientating programming, but I don't think the other way around producing programs inside the virtual world using objects. They might be, I haven't come across any, but I haven't done a lot of looking recently, but that went down quite well with some people here.

AC: Yes, It's like Mr Ben, going through the mirror.

KF: I don't know.

AC: It's a children's cartoon, he goes through a mirror he turned into different existences.

KF: We also had the concept which we never built here was the idea of a subway, I think that it was lifted from, because all of this was lifted from Neuromancer, this was Rob and the others, but we had the idea of if you imagine a hole in the ground with a little signpost on the top of it that says 'if you pop in here you come out anywhere else'. I tried to build that for ages, we had the problem with the buffering on the modeller, it wouldn't allow you to produce a, something that had mass, you could see inside it but when you looked outside it was invisible. I think you can do it now, it was a facet sorting problem, but what you would effectively do was, go inside a wedge, a wedge of cheese, with a hole in the top and then when you go through that surface there, you disappear and pop up somewhere else, which has changed the viewpoint, do you see what I mean? Holes in time, or holes in space.

So you could jump from this position in this world to another position, at the moment I can do that by pressing viewpoint buttons, right, but humanly, it doesn't mean a lot, you know there's no, but if there was a hole here, it could go into and I knew that every time I went in there I'd come out here, that was something humans could understand and we were going to get a way of navigating like that, we never built it because we've didn't find it easy to do in the tool, I could probably do it now, well I'm sure I could. I think it is mentioned in the patent but we didn't actually visualise it.

AC: Did the interface demonstrate structure or relationships between entities or information?

KF: Yes.

AC: In what sense though, did it...?

KF: What ever you want to make of it. We did it physically and the physical manifestation could be a social relationship, a physical relationship it can be anything and you can mix them, which isn't very easy to mix in other media. So this link from a-b is a physical telephone line this link from c-d could be a monetary relationship and I think you can mix the metaphors quite well without confusing, in a virtual world.

AC: How was it represented, the relationship though, is it always the lines are connections or are there other ways?

KF: O' it is whatever your imagination could do, we weren't trying to, we found that we could put that visualisation of a lattice up, some people thought of it as a tube map some people thought of it as a data map, some thought of it as bond strengths between molecules.

AC: You can view that from different perspectives as well?

KF: Well that is the model just viewed from the top, so we haven't generated lots of pictures here what we have generated is one model and view it from different angles, so we've actually got effectively infinite amount of pictures, from one model. And that's the difference isn't it?

AC: Do you think that it would be easier to convey those relationships in three dimensions than two dimensions?

KF: Pass, horses for courses.

AC: In this particular instance trying to show relationships between information...

KF: Well, I think that you may have to go one step further like we did with the call waiting in the sense that it was easy to visualise a call as a link between a and b, but in fact when you tried to show twenty calls, or whatever, you had to actually think of the call itself as an entity not as a link between a and b. So in this case, just because we *can* show a link between here to there, doesn't necessarily mean it's the best way of representing that relationship. Yes, its maybe better to show that next to that next to that next to that rather than being linked as showing a...

AC: A community of relationships?

KF: Yes, all these people around an object is a link, you could have shown them as little links to lumps like a, couldn't you.

AC: Yes.

KF: You have got horses for courses. The bit l like in here is this, can you see the little white dots?

AC: O' right what's that?

KF: Well they are a set of code which randomly takes a piece of data, but its actually a bit like a rodent infestation because we can't find that bit of code anymore, but it still goes, starts up. We did it but we can't find where it is anymore. Do you see what I mean, we have actually got a virtual world with sort of dross in it, that I can't scrub out! And I did a world called grubby world, did you ever see that, everything in here is perfect and I was trying to show that some things when they get used a lot get grubby.

AC: Do you have that one on file?

KF: Probably, I only did it to one icon but it didn't half get some ideas going for people. It's not in my standard, O' it'll be in Kim, it might be in Kim, Grubby, Grubby. Nothing earth-shattering about it, O' I changed some of the other bits, here we are, you know, it started to get damaged you know, burnt out icons. The whole concept of use you know, things you get, I also changed these centres of information changed those, I started, this was the inverted thing, something that you can't actually see, its rotating sphere but I put some real world attributes in the middle. I put some trees, what did it do to the scale of the carpet, you know, all of a sudden it was wrong, but which one was right: Are they small trees or is it a big carpet?

AC: I think that a lot of it as being like magic tricks...

KF: Right yes, when you strip everything away and you just put two things side by side and we were looking at, Rob and I were having a whale of a time, looking at some of these bits and pieces, yes. This is one of the weirdest ones I have, lets see if I can get over there, that looks like a mountain range, doesn't it, and it looks like a serious mountain range, which in VR terms is terribly difficult to create, but in fact they are flat objects, flat textures, but positioned in such a way that as you fly over them they appear to be 3D again, we were trying to do complicated things in, now that's another thing, this object is in fact a rectangle, so that can be seen behind it, but I had to put a sound on the mountains so I knew that. But if I move around here, maybe I'll move quicker this way, I can actually get to that object, its pretty difficult, that object is now sticking out beyond there, no, the mountain is still in front.

AC: The mountain is making the noise?

KF: Not the object, it sounds weird but. That object is now sticking out beyond the mountain. Because the object of the mountain is actually rectangular not the mountain shape, and there were lots of funny…

AC: Is that see through?

KF: Yes, where as the object itself has got that clunk, clunk on it. All sorts of anomalies started happening when we were playing with the textures, anyway, that was grubby, can you see where we were getting seriously weird? Yes, there you are they're vertical, it's the same world just modified.

AC: I think we are going to need to call it to a close.
If I finish off here and then maybe I think we have some time booked in tomorrow.

KF: I'm not here tomorrow, I could be here in the afternoon.

AC: Perhaps understanding where the edges of this existence was were there ways that you employed the visual to do that?

KF: We didn't really consider that. That's really rather naughty I suppose, we always had the ability to reset the world and go back to a fixed position. F12 you know, fly off somewhere.

AC: And reset world was a very important thing?

KF: Yes, well it comes with the program. We found it was when people got in a right muddle they could reset the world, something you can't do in reality. It would be lovely.

AC: Ok shall we leave it there?

[second session]

KF: We've got 55 minutes starting from…right.

OK well, we went through the previous questions and when we paused we had just started a separate section.

KF: Right so lets start again.

AC: OK, Is this visualisation which is and example of something of an ongoing design or a finished concept?

KF: This particular one is finished and it was brought up to a demo level. And it was moved from there into a visualisation on the dealing desk and then added to on the dealing desk, 2010 dealing desk.

AC: Is there two dimensional information displayed?

KF: Yes, if you go, what we were trying to say to dealers, or anybody who had a system, that you don't actually throw away what you have got at the moment, you bring it with you. And we put it there so that you can get at it like you can in the normal windows system but bit by bit we were going to erode the relevance of that by having more information available through the system visualised in different ways, but horses for courses, there's an awful lot of skill in interpreting 2D information already there and we wanted to still enable that and then build on it, rather than substitute one for the other.

AC: Is there any textual information?

KF: I haven't added textual information to objects, it's very easy to do, its also extremely confusing for the user, because in the way that this software puts it on, its like a billboard, so where ever you look at and object it will have a flag of text that follows it, it won't. Its not easy to render text in perspective like a silicon graphics machine can, but if you look at the usage of, when you are running it with text on and with not on a silicon graphics, you will see two thirds of the processing is going on putting the text in perspective, and much of it is confusing. I think it is more relevant to put text on from distancing so when you get near a thing then you grow the detail and one of the details you can grow is textual information, yes, but I haven't done very much other than just, you know, flat graphics in this world. It is quite possible to put text in various ways in the world.

AC: Were there any design issues involved in creating that two dimensional text or is that easy to do?

KF: You can actually run live, pcx files, flick files, avi files on a surface in this world, not just cut like, this is a billboard, so as you fly round it, it still stays parallel to you. But you can actually attach these text and graphics to surfaces in perspective.

AC: Could you put something like that excel file on that?

KF: Yes, yes, it would not be as clever as that, you would be able to put the information from screen captured online and placed as a file but it is not like attaching a window to a surface. There is a demonstration I've have got which shows you windows running on a computer inside the virtual world. And the windows that are on it are actually windows as if you were looking at the real computer. So you can click on them and run them but it is very much more complicated than windows. I think what I was trying to do was to produce functionality which you didn't require windows inside the virtual world, you were giving more, not more but relevant things to do in the world relative to where you were, whereas windows is very powerful totally non specific.

AC: And the three dimensional information that you have there, how would you characterise the three dimensional?

KF: In this I would characterise it as totally abstract, with a little bit of reality dropped in just to give it a bit of edge, I mean those things here like there's a clock here which is telling the right time and its an ordinary clock and it is suspended in free space and that was put in just a little bit of a jar. You know all of a sudden you are going around a virtual world and you are in symbol world and all of a sudden there's real things in there. That's quite fun

AC: It's interesting that it is an analogue clock rather than a digital one as well.

KF: Yes, yes.

AC: It's very much more real.

KF: Very, and it ticks and you can hear it where you are in the world relative to the stereo position of the ticks, so it does help as a positioning thing when you are a bit lost sometimes. I'll see if I can get up close to it. Yes, I'll try something else, it hasn't got click on and fly to on it, which is what most of this world has. It's easy enough to do it, just a line of code attached to each object. I can't fly up to it quickly using this technique, no.

AC: Are there any animated aspects within this world?

KF: Yes, lots of them. There's these links here flashing on this, just a colour change flashing, these objects are rotating, here, and I'll just shrink this down a bit because this is only a 120 machine so it's a bit slow, I'll just, it won't allow me to, there we are, now that's a rotating object, um, this particular object, is very slow machine, yes, has animations, this is Neuromancer's ice, do you know, they call it, it's a security device, shoots off around the thing. And you can go, if you go inside it, you have gone inside the secure environment, if you have access, if you back off away from it, then you can see the contents, its only when you try and get in that you have a problem. Its very slow because I am rendering such a big screen.

AC: The animated aspects, what was the reason behind the animation?

KF: Convey more meaning. Its not animation in the sense of having a story and telling a story, its not that, what it is, is action reaction animation, so in this case some data paths are just moving or flashing and in this case it will only go through an animated sequence when you get near it, whereas the rotating bit around here somewhere, there we are, is rotating constantly that would be a normal standard rotation.

AC: Right, and was there a particular purpose behind that one and the others or was it just to give a...?

KF: The other, the ice one was done by other people and the reason behind that was to show access, limited access, type in a password you get in and the ice drops away. The rotating one was actually to, to, moving objects attract your attention, and we were looking at static objects and moving objects and its edge detection that you are good at, so it's got lots of facets and we were looking to see how small it could be and you could still pick it out. They were playing, nothing other than playing.

AC: How might the mode of interacting with the information be considered is it free roam or is there set paths?

KF: I don't think there is any limit to it, we have got some set paths. Those are views, multiple views, set paths, let's make this a bit bigger, yes, yes, flying around set paths, round the information or whatever, yes, do you want to zoom in, yes.

AC: Were some easier to use than others to use did you use set paths for a particular reason over the free roam?

KF: Set paths are very easy to do. Effectively you wander around the world setting points and then ask it to join with curves and it will do a set path and you just assign it to a viewpoint number that's easy, to dynamically set a path we haven't done that as yet. Its not a problem, you know relative to some information is added to the world and it flies you to it or something. We can do that but we didn't take this demo that far, at all, that's only really happened in the last couple of years, where we can actively drive this world from outside and therefore un-predetermined paths could be generated, couldn't they. And we haven't done that, except in the new 3D retail demo, where when you download and object and place it in the world, download a sofa put it in the world it flies you to, so that object just placed is in the middle of your viewpoint now, so what you could do is place the sofa behind where your viewpoint was when you switch the view point from 2D back to 3D, view of the room, it would be behind you. And we thought that was pointless, now it automatically sets the object as the centre of the viewpoint. So that might be said to be what you are saying, its got to feel intuitive.

AC: Are there hyper-links in this interface?

KF: In this yes, this is click on and fly to, and I have got particular shaped objects here which I have used consistently but aren't a national standard or whatever, but if you click on these, it jumps to another world, and if you click on here, it will jump back.

AC: Was there a particular reason behind the shape that you were using there?

KF: Yes, it is nothing logical, nothing naturally logical, what I was trying to do was I was trying in Call Waiting to actually make it look like a bagatelle machine, a flipper, right, and so that when a call came in it bounced, bounced, bounced, if it wasn't answered it was flipped somewhere else, so I made a flipper object and when I came to do these 'jump objects' as they were called I was going to have it sort of 'boing', flip, but instead, so I put the objects in but I never got them to flip. So that's why they look a bit like coffins. They were actually made to be a pair of flippers, like a bagatelle machine.

AC: And the colours do they have any link to the places you go to or is that?

KF: Only in my association in here.

AC: Can the user go back in time, replay things that they have already done or are they fixed in natural time?

KF: The actual world has the ability to be reset and that will take you back to position bit the same thing in the demo that we have got so time wise, yes it will, if I press the reset the world you will see some data start coming out of here, right, and if I reset the world again, it will reset it and it will start again, so I think that is the only clue I have that it is sequentially, this data wanders aimlessly around the world, randomly, not randomly, I think it must go some kind of mathematical path, but we can't actually find it now in the code to delete it so it is actually a sort of piece of electronic flotsam, I can't find it to get rid of it. And because it moves I can't click on it very easily to highlight it and when you put it in the toolkit you can't get it. So other than going through all the code I can't find where I did it. I actually copied it from somebody else, put it in my world and now I have lost it in there, yes.

AC: Were there any other modes of navigating in the space?

KF: Yes, we've been through them before have we or? There's about five ways of navigating around the space one is click-on and fly to, the other is, this is a combination one, that's click on and fly to, so you click on, fly to the object, and then the other way of navigating associated with that, is that this is a virtual lift, so you actually fly into an object and you have got buttons that you can press, and it takes you there, that was another way. The other way, all associated, there is click on and fly to, is this pre-set path on a magic carpet, so you can get off and fly around on a magic carpet, and while you are on it you can, tilt, look round and it slows you down while you are looking around, and then you get off, that's that. And then the other way is, a lot of combinations of click-on and fly to, if you fly through these objects, through the loop, it automatically takes you to the next loop and on, and that's the do and undo thing, and so you can fly one way and go that way, fly back through it and come back the path you have just been and they are predetermined paths, that's that. And the other one is the jump cube, which is those flippers, you click them and it jump loads another world on top of where you are and always loads you at the initial viewpoint into that next world, so when you leave one world from anywhere you will always enter another world as it is loaded in the same place every time, so you, unless, I don't have a way I don't believe, of running two worlds at the same time, yes I have, if I run them within the browsers, it wasn't available then, but I could have two windows of a browser open, what's interesting is that the worlds will fly, if they have got animations they will fly their own paths but when you are actually flying your viewpoint you can only fly the active window, can't you, even though the worlds may be changing from external influence, you can actually only yourself as a user with two windows influence one at any one time, that's weird, we had multiple windows running on the desk once and they could be actively driven by different external sources, but you yourself could only fiddle with one at any one time.

AC: Do the interfaces demonstrate structure between entities or relationships between information?

KF: Both.

AC: In what ways?

KF: You said, it, structure between entities or…

AC: or relationships between information?

KF: The entities could be represent whatever you like, when I sell it to customers, I talk about those entities being information, so the relationship between the entities is totally synonymous with the relationship between the information, if that is how you want to build the world, there is no difference, one is a metaphor for the other, in fact not even as complicated as a metaphor a symbol, if that is simpler than a metaphor, I think it is, this one is a symbol for the other, and in many instances it can be the other, do you know what I mean, you could put the information in there you know a graph going up and down, and that is the information isn't it, so the information is the object, I don't want any translation if at all possible.

AC: Was it easier to represent structure using three dimensions, two dimensions or did it not make a difference?

KF: We did when we were looking at planning things and information lattices, you know, if you take a normal structure you have a hundred folders, well we did it with ten variables, folders, with ten variables in each, that was about the maximum that you can put on a 2D page, in here you can have a square of that, easy, and still know where you are, yes.

AC: How did the user in the space relate their known aspects to the potential of the space, did they find it easy to know where they were in relation to where they could go?

KF: No, one of the things we, if you take a totally naïve user, what we used the magic carpet for, was what I would call a 3D equivalent of an index or a contents list, and what we were saying was if we brought a naïve user into this space they would want like a contents of a book, they would want to find out where things are, what this magic carpet could do was ride you round all the contents of the world and put you back where you started. And that was an idea we didn't do it all the way, but that is how we sold the idea, was that this magic carpet was the equivalent to a contents page and you could go back to it time and time again. And it would take you to something on the path and anywhere along the path you can press the spacebar and you're there so it is a bit like contents with auto search, yes.

AC: Did the animations used change scale at all? Its not animation in the truest sense but the animated objects did they use change their scale to convey meaning?

KF: No, not in this demo, we were, if you think how many variables we are currently playing with here, we did on the other demos didn't we, with the 'em-cons' where I was showing how you could change the size of an object, the proportions of an object. You get some really weird things when we were doing a data driven graphing, where a share price would climb, you know, two hundred percent and all the others would start dwarfing and you lost meaning then, and the guys at Syntegra did some really neat algorithms to keep everything human, because we have got three dimensions, colour, sound, position to play with. And you don't have to just 'whap' it one in one axis you can do it other ways, so when things do radically change scale of one to the other, first of all it confuses you, in the sense one thing we had with that was we thought all the others had shrunk not that one of them had got bigger. There was nothing fixed scale in it for you to relate it against. Maybe if we put a ruler or a matchbox or something that you know the scale of, there is nothing in there other than the carpet. The carpet was quite good at scaling people, people actually could use this carpet, because they knew it couldn't be bigger than, you know it is not the size of a…

KF: Putting in a scale for a world, in my grubby world, that had some trees in and mountains we put in there and they were very good at scaling a world, they don't have to be obvious, you don't, you know this is two metres, and there's a ruler, it has to be something you encounter.

AC: Were there any human characteristics in any of the animated worlds?

KF: In this world, no not really, what the emotional icons is all about that, and so is call waiting, but this hasn't I haven't built a world with all of them in, I have been tempted to but I never had enough horsepower to get all of the characteristics of all the worlds I have got all in one place. We could do that now, yes, you know, everything animating live data flying, click on fly to, animated surfaces, lights moving around, I mean you could do that now but you couldn't then. Also, you find that the world is more busy than the information you're trying to render. Some of the comments about my animation of Call Waiting and Amanda's, is that Amanda's is much more busy but has lost a bit of the clarity, mine is not anywhere, doesn't look as professional but it was very clear.

AC: Was there any emotion animated in this?

KF: No, some came from one or two of the things, if you get a wobble at the right speed it is amazing, anything that's you could take a teapot and wobble it can make it look angry, or a bicycle the wobble speed, that seems to be one, flashing of one colour to another can invoke you but it wasn't intentionally put there, not in navigate.

AC: Were any aspects particularly mechanical in any of the animations?

KF: Yes the whole thing was done as if it could physically happen. There aren't unreal things happening, you get onto the carpet and the carpet is still there as you fly around, you approach the pyramid in the middle and the walls grow and cover it they don't just appear or disappear. When you click on and fly to the head rotates and then heads off. So that sort of thing has been made very real.

AC: Were any other features involved in the animation parts?

KF: In the animation parts? I don't...

AC: ways that you could describe it?

KF: We found that we could replace the need for animating some objects by making them have a sound, so you know when you push a button on a dead screen and you see a drop shadow or it moves, you can get away without having to do that in this case because it makes a sound. I'm not sure which is...

KF: You need good feedback, like that, yes, so that is the only instance, I think that sound is the only thing we never really got our head around using well and we are going to now, because it is easy to deliver, we know how to do it.

AC: Was there any particular reasoning behind the animated aspects?

KF: All of the things in this navigate world were to give you a feeling of being *in* the world not looking at it. And after a very short time you could find your way around, there were things like landmarks which were very important. Which, this was done a long time ago, but it was about the time things like landmarks were becoming important. There is a difference in the world if you have it live driven is that you need landmarks in the world anyway and then you add other data around them. Don't move landmarks, else people get totally confused.

AC: Were there particular characteristics about those landmarks that you

KF: Size, spacing, relation to each other, sometimes you could be spinning one way round or another way around, or the way the sequence that you go past things is important. I always go past the yellow before the red before the blue or something. And you would remember where you are from that.

AC: coherence to it?

KF: Those bits are. You could scatter bits of data around them and they could be different all the time. But as long as those remain constant. We did try and do like neighbourhoods, that's what we tried on that one with all the banks, different bank names. I was trying to start up well it was Rob Taylor Hendry's idea of neighbourhoods, and then that developed along with other peoples into information islands. On another project, didn't it, were you could group things in the world and then navigate between the islands. That's, well Paul Rays had something to do with that. But there was John was to do with that I can't remember his surname.

AC: The Animated aspects, were they mainly for feedback, instruction and realism?

KF: They were done initially for fun, because it is very boring looking at a static world. And with icons they were to represent, have meaning, or shouldn't the animations shouldn't contradict their meaning, the animations were done to, not just for fun, and that, but to make the world interactive place so it wasn't static as you moved around, things would happen. And in the mirror they did even more of that. You know the mirror project,

AC: Who was involved in that?

KF: O' half of the unit, Matt, Paul Rees mob, Amanda she won awards for it, and that's the shared spaces stuff and they had a very good thing, the problem with this is that you have no concept of time passing, that's one of the reasons I put a clock in there, because you don't know what time of day it was. And what they did was they had randomly generated events during a shared experience with several users in the world, so you could have a benchmark for time, so it was before Elvis Presley appeared and after Elvis Presley appeared in the session or did you see JFK's car, because they had him appear in the world and drive through the middle of a supermarket or something. So there was an event, that was nothing to do, now we didn't have anything like that, in this world, it was the same every time, all of the time, the same animations going on, there was, you could spend hours playing with it and think you'd spent minutes.

AC: Did any of the animations employ real world characteristics?

KF: The clock, and the Reuters screen in this one, and the BT logo. Reuters screen, carpet and the clock.

AC: Was there object collision and things like that?

KF: No you could fly through anything it would affect objects, yes, I could fly up to something and it would trigger it. Like if I fly onto the carpet, right, there the first click takes me near it, if I now fly onto it without clicking it, once I am on it, it picks me up, is that what you mean? Its space, taking the viewpoint with it.

AC: Were there examples where the animations could break the real world conventions?

KF: Yes, yes, but only as if they were, they didn't sort of, they kept you vertical and all sorts of things like that, you could go through a wall, I didn't bother to open doors to get into objects, I just went through the side. Yes that would be unreal.

AC: And as an individual do you always have gravity?

KF: You can fly up and all over. You can turn it on and off, there was one trick we do the only idea you get of space and relative proportions in here is the speed at which you fly around the world. Ever so slow. Here we are, I'll just speed up the space-mouse, there we are, you see this one turning green, that meant that you could go inside this one, and it would say welcome to the digital bank, how can I help you Mr fisher, what we could do is by just changing the speed in which you fly around the world is, slowing it down made the world feel bigger, relative to other parts of the world. So what we did inside this cube was, its not very easy to see, but you could make it feel ten times bigger by flying at a tenth of the speed, yes.

AC: Is that relative to where you were?

KF: If you're outside you are flying at a hundred miles and hour if you go inside you are flying at ten miles an hour. And the whole space you are in now feels relative to the outside ten times bigger and it is all within the same world, that's what we were trying to do. The reason we did it actually, was its only a tiny cube, and once you go into it you can fly straight out the other side, so we actually made it change the rate at which you flew when you went....

AC: You could add that speed change anywhere in the world or just in objects?

KF: I think you could probably do it with invisible objects. And it would seriously throw you [laughs]. If you didn't know what you were entering and why things had changed, you could make sort of distorted pieces of space.

AC: The effect where you are slowed down

KF: Yes, yes I hadn't though of doing it like that. We always did it because it was easy to do inside defined object, we only did it in the one object, because you have also got to, to change the speed you also have to change the size of objects as well. To restore it back in proportion to the world that you have just left, and this is a world within a world. And it was bad enough to get people to this kind of perception to take them a bit further might have been a bit, well it depended what we wanted to do, whether we wanted to get sponsored or whether we wanted to be sent back to college [laughs].

AC: Shopping does that with some areas that are highly polished as well as carpets to slow you down.

KF: Is that what they do, its then obvious to you, yes I don't know. But if you did it without any seams in the world like, if I flew across here all of a sudden the world scaled, because it was speed was used to change scale not to change your progress, your perception that we wanted to leave was that your progress was the same speed but you had just gone into a bigger space, if you can have a bigger space than infinity [laughs].

AC: How is the presence of the user demonstrated?

KF: None, other than your viewpoint again, you have got multiple viewpoints, and I as the user am the viewpoint. There are other users represented in this, I had started to show shared spaces, in the sense that, I wanted to show that round a piece of information there were in fact other people in the world, can you see that, it's the big button in and out, its very difficult to see, and you can see these people here, its very difficult to see there, shall I zoom in, no, there's the, were like avatars, these are a piece of information with tiny representations of people around them.

AC: And did you use real world characteristics for them?

KF: Male and female, but nothing, what they were supposed to do was distance, and have the picture of the person as you get close to them. I didn't know how to do that but the software can, it was an early idea.

AC: Did the avatars break any real world characteristics?

KF: Yes, they are spinning all the time [laughs]. They had no content they were just outlines. They had very very minimalist human, I did in another world have some real people as an avatar, it didn't really add any value. I've got serious doubts about human avatars.

AC: In what sense?

KF: I think you need waving arms. I think you need to use the characteristics by which you recognise somebody, but you don't have to have all the gesture and everything like that. That's where I am at odds with the forum people. I think the head, a picture of the head, not even talking, is to do with location, whether you are… gaze awareness might be useful, am I looking as an avatar at this person or that person, some have done it with lines from avatars heads, have you seen that, who they are pointing at? I think that's horrible it looks like you are pointing a gun at somebody. And I wanted to avoid in mine as many of the human things as possible, and boil it back down to an essence.

AC: That was deliberate?

KF: I didn't feel for the extra agro that it would be to get an animated human avatar that I was getting any bonus, and every body else was following that path, and they were using massive machines and getting not an awful lot out of it, they were having great fun, but I didn't feel it added anything to the experience. But that is my opinion, not, not the consensus is that you add human characteristics to it. But there are so many conflicting refined characteristics, that a bad avatar will give you lots of wrong information, that's opinion.

AC: In this space can you see yourself, can you have multiple existences?

KF: You can have multiple viewpoints but you can't see yourself not in this space. You can in emotional icons, there is nothing to stop you as I have said I haven't combined the attributes from different worlds, it wasn't done intentionally, you know, avoided intentionally.

AC: In this space can you leave objects or tokens in the space?

KF: No.

AC: Can you pick up anything in the space?

KF: No, It is purely about navigating around the space and using what is in the space to help you navigate.

AC: Would the space be a multi-user domain

KF: The original model wasn't but it could be, easily.

AC: How would people relate to each other in the space?

KF: Purely positionally, and I would imagine that we would trigger a proximity ability to chat but that hasn't been done. There is nothing to stop it, its ever so easy to do, with this particular software that facility already exists now, it didn't when the world was built, but it does now, over the net.

AC: How would you describe the overall visual appearance of the interface?

KF: Well it is all lifted initially from a model of cyberspace done by Superscape. Cyberspace being William Gibson's, from William Gibson's Neuromancer, and then on top of that we, because most of the people doing this work have read it, and this was an embodiment of it, and then I added things to it, carpets windows, so we used some of the basic things that, the cones the tubes and things and dropped our objects in it. So that's where the visual appearance came from.

AC: Was a generic style intended in the visual appearance of the space?

KF: No, it was supposed initially the space was designed to match the book, or one person's interpretation of the book.

AC: That wasn't something that you would deliberately build within

KF: Yes, I think we are, because those who want to look at it and talk about the space, having different attributes, if you make it look the same as cyberspace they already understand half of the story so you are only selling the new things, not old, not the whole thing. So most of the people working in VR, Data navigation had read Neuromancer, knew all about ice and things like that.

AC: Its interesting that the virtual world was explained in words.

KF: Yes, yes before it existed as a real thing.

KF: I think NASA Eames could have probably done it before William Gibson had done it. It's probably where he got it from was the guys in NASA EAMS research lab, were doing this stuff before anybody else had the computer powerful enough, they were doing head-mount display stuff, you can run this world on a head mounted display with twin view.

AC: And how does that affect it?

KF: Doesn't add anything. I've tried it and it didn't add any thing to me, and it has proved that I can see in stereo.

20% of the male population can't see in stereo, they can see stereo images but their brain doesn't map it to give them any more information. Something like that, you have to look at, who is the ergonomics guy, Dreyfuss.

AC: OK. What was the reasoning behind the key features of the visual style of the interface?

KF: As I said, Neuromancer.

AC: So, and were some influenced by the Library of objects?

KF: Yes, and the capability of machines to render it and a desire for clarity, messy world you have got to dig around to find things in. Nice clean crisp world and you can get your ideas across easily.

AC: was any of it in relation to users' conventions?

KF: Yes, that was the book and we tried to do quite natural things happening, we have kept the number of variables down, I've turned off Yaw and pitch, when flying, so you don't flip over, things like that were important.

AC: was it always clear what kind of visual representations would be used?

No.

AC: In what way?

KF: How would one visualise a virtual lift, you could have had doors, it would have had lights, it would have had buttons, it would have had cables. Do you know what I mean and effectively, what we did was we took it down to a cube and then we went inside the cube and it does something a lift doesn't do which enables you to see outside when you are inside, where you are going, so we could sell it as a lift, it did what a lift would do, but it didn't do any of the mechanical or physical constraints of a lift. So that was, looks ever so simple now but it was difficult, the temptation was to just build a metaphor, and I was avoiding metaphors.

AC: Was that much harder?

KF: Yes, its jolly easy to make a lift and call it a lift.

AC: how did you come up with the ideas that weren't obvious?

KF: We started with the obvious and stripped off all the bits until it wasn't obvious what it was, so we did it by reverse engineering, we built a lift, we built this as a model and then took away all the bits and did it still look like a lift, and did it still work? Yes, and then take away some more bits, like value engineering in a virtual world, I wouldn't say that, that's a bit over the top it's a lot easier to do a simple cube, yes.

AC: Did you consider many different alternatives when it came to choosing ways of representing things or?

KF: We have got, as I said before, we have got about six sheets we did of ideas just brainstorming about three or four of us in my old office years ago, and we could probably go back to that sheet now and pick off another two or three ideas, we worked up about half of the ideas, its in the emotional icons file there's some tatty old A2 sheets.

AC: Was there any reason why there were ones you didn't use or was it just time?

KF: I think some of them we couldn't actually build in this world. And we had got a pretty good hit with the ones we did build and there is there's no point, as we found with icons, having 1400 icons, when the problem isn't icons its navigating. And with navigating we wanted brake accelerator and clutch. We actually started believe it or not, I wanted to have the navigate equivalence of cut, copy and paste. You know, because you use cut copy and paste whatever you are doing on a computer it tends to be cut, copy and paste. And we were trying to find the virtual world equivalence of cut, copy and paste.

AC: Because the idea of copying is something which is very difficult in the real world but instant in the computer world.

KF: We haven't done that here. That wasn't relevant to navigating around information.

AC: And time was represented in the interface by the clock

KF: No, no, it wasn't represented, the clock wasn't put there to do time initially. The clock was to give you a bit of a jolt.

AC: What was the advantage of jolting from their illusion or was it just playful?

KF: Playful, all of a sudden you came across a ticking clock in a virtual world, what is going on here?

AC: Dali?

KF: Yes, somebody, I think Gary made one drip over a branch, the hands still went round, it still ticked. I think he's got it somewhere.

AC: In that sense the clock that you had is realistic

KF: Was a standard clip object. I dint make it I just dropped it in the world.

AC: Did the space have real world time characteristics like night and day?

KF: No, we would have liked that, I didn't know how to drive the colours on the horizon from the clock, in the, the computers clock. There is nothing to stop it.

AC: Something you could do now?

KF: Yes, a bit confusing if you are accessing a web site from three parts of the world, what time of day is it if you have got a shared space?

AC: Around the world shared space

KF: But how could three of you in different time zones be in the same space together and have different times?

AC: Ultimately, then you have one of the main problems, of making things look like reality is if you represented it exactly

KF: Which is why too many real world metaphors get in the way of what you are trying to do. Strip it back to what it is you want to do in the World and represent them rather than spending ages, like some people do on multimedia spending a lot of the processor power putting drop shadows on the buttons, it's irrelevant.

AC: What was the purpose of the time metaphor then?

KF: We didn't really, we knew time was actually, we were looking for navigation tools, time was one of them but we never really got a way of handling it, this navigate has no time other than the clock which was current real time of the machine you are on, it be good to use time as a navigator, and in fact with the data that we used on concept 2010, as it comes in it forms a bar graph, and when the next bit of data comes in the bar graph that you have just had if the data has changed, moves back one, so if you fly down and look at the side of the bar graph, you see history over time, do you see what I mean, its like toothpaste coming out of a tube. With a variable front.

AC: Was space represented realistically or was that more symbolically?

KF: It was real compared with cyberspace in Neuromancer, that is about as real as it gets. So I wouldn't say it was anything on earth, it was a cyberspace representation of cyberspace, as described by Gibson.

AC: The things that you were referring to the reference, that you were drawing inspiration from, that you were drawing meaning from. Where would you say that the visual aspects had come from, had they come from real world object or from conventions?

KF: Conventions, I think you could say what William Gibson, how he described cyberspace struck a chord with a lot of people, and became a convention, this was done a long time after that had been read by a lot of people, so it would be a convention wouldn't it. There was nothing novel in us interpreting it.

AC: Were some things easier to represent three dimensionally than others?

KF: Yes.

AC: Have you got examples?

KF: Yes, I think not just three dimensionally but interactively. The concept of ice, here, here, this is a concept that as you get closer to something your access is denied.

AC: Did it actually have sound with it?

KF: We didn't on that, nothing to stop it, its ever so easy to do, but that concept was described in the book, very difficult to describe, other than in reality.

AC: Were there any that were particularly easy to represent?

KF: That was.

AC: O' that was easy, any difficult things to represent?

KF: I think the most difficult to represent was the concept of a jump cube, which was that you click on this and you go to another world and we tried to show it visually and it just didn't make any sense, because the whole point was the moment you touched it it started loading another world. So if you touched it, it wouldn't move, because the act of touching starts loading another world, so what we did was we actually found sound was the best way of doing it, so in this case, if we get over here, I can navigate, instead of this object when I click on it doing something, we got it to make a sound and by the time the sound had finished we were in the next world,

AC: Was that important to users understanding?

KF: Yes, well if you see what happens here, you get the feeling of the meaning of what was happening here, you see when it goes clunk bang it goes to another world. You expect something to happen. This was the same action but with no sound, do you get the feeling?

AC: Sound is meaning?

KF: Meaning, any shaped objects, or even entering something, we couldn't create a movement or something, we didn't find it easier, it was something we tried.

AC: And were there any mental models used to..

KF: The whole thing is mental models. The whole thing is, not metaphors necessarily, but mental models. And then it was how quickly you could share that mental model, with one demo, if you could demonstrate it once and the next time the person found it in the world and knew what was going to happen you had cracked it. The whole purpose of this world and what we were doing was to reduce the number of foot of shelves of manuals that was the whole remit, you know the remit in BT was we make money when people use things, and things that are easy to use get used, so we make money.

AC: Things that are fun to use get used.

KF: Right, so what our whole remit here was to make things easy to use and then they get used, fun to use and they get used. And to get rid of all the paper and duplication of things, having to learn five ways to do the same thing.

AC: Do you think that this particular one was successful in doing that?

KF: It opened up peoples eyes to the fact that on a PC which at that time only ran windows 3.1, you could have another way of getting at the same information that was fun easy to use and intuitive, whereas windows 3.1 took weeks to learn. This if you could learn the brake clutch and accelerator of getting around the worlds you could get round anywhere, whereas that's not true in windows, it doesn't do everything consistently. We were trying for that.

AC: Did you consider their future actions?

KF: And we intended them to build it to be their own mental model. So the interface to the information would not necessarily be consistent on different people's machines. You would have the brake, clutch and accelerator would be the same and getting around the world, but the actual structure would be totally dependant on how a person, not configured it but actually, it grows, only when we went inside the lift, and it said this was a lift.

AC: Was there any generic style in the audio aspects?

KF: My only intention in the audio was not to pay any body royalties for them. Everything you take off of Microsoft they will go for you. So we actually created all the sounds, we had a musician, sounds we used. O' the tick, tock on the clock, yes.

AC: In relation to sound?

KF: I don't think is has been used enough, we intend to use it a lot more. It is terribly difficult to use in an office environment because of it disturbing other people. So there is probably a hardware issue with using it on desktop systems. In the sense that you would probably have to have a cordless ear-piece, stereo which are non intrusive to wear, and that was where that was all tied in with this. And that headset can be a telephone it can be a whatever a messaging system a tannoy. And you get into a whole realm of things, the other side of it was putting sound into it, so the world could actually recognise your voice, and we do a lot of that, dial, Andrea..

AC: That's more ongoing things?

KF: They are just a matter of stitching them in they all exist, its just a way of I see again a way of flying round information is better than from window to window. You have only got to task sheet of: how would you, with a current computer invoke voice dialling? I mean, you would spend twenty minutes clicking buttons to get the right window up before you could do it, maybe. It was a demonstration to customers, demonstration to colleagues, opening up conversations with customers, and then let them pour out how they think they would use it. It was never done in any human factors structured way it was done by myself and several other people over two or three years, listening, demonstrating it to customers, getting them to talk about it.

AC: Was feedback to that pretty…

KF: Great. They love it because each person, its broad enough, for each person to interpret it in their own circumstance.

AC: What do you perceive to be the main successes of the project?

KF: That it got BT talking to people in customers organisations, who we were not normally talking to. We normally talk to the IT, the telecom managers.

3D RETAIL CASE STUDY TRANSCRIPT

KF: 11th May 1998 so this is about a year and a bit old, longer than that actually. What we have got here are four areas inside a browser. So we have got a standard browser window, and it will run in either internet Explorer or Netscape. We have a banner across the top which is for branding. We have a banner across the bottom which can have function buttons in. We then have a 2D scrollable catalogue window. And then we have a 3D window here which plays a 3D model, on the local computer. Right, And how does 3D retail work?

Basically you will go to a login procedure and you will get onto a particular retailer's site and you will have loaded the plug-in that plays this as part of joining a retailer's mailing list or a retailer's customer list and then what you will be able to do is pick standard rooms from this side like fabrics here, you will load a standard room which will be not bare but everything in it will be white, white curtains, white carpet, white sofa or whatever, white walls.

And then bit by bit you will be able to pick up the fabrics the bits and pieces over the internet and load them into the application, and therefore you will be able to use it as a 'what if' tool, what if I had these curtains with that carpet and so on.
So for the trial that we are doing at the moment, you will just be able to have standard rooms here but in the future you will be able to make your own rooms, either by a service delivered over the internet or from what is currently available, a piece of software called 3D interior designer two, build your own real room, save it, and then load the curtains and carpets into it.

This particular model is in fact my living room and the reason it's my living room is that I wanted to be able to make judgements of whether it was a good likeness or whether I could make aesthetic judgements, and so I have got photographs of the room and the actual model of the room and you can compare the two and it is very close to the real room itself.
Inside this process then the objects inside the room, if you click on the curtains you will see that they work, and these curtains were in fact photographed scanned in and just stuck onto a surface in this world.

Objects inside the world were alive, so this particular clock tells the right time relative, and I don't know if you can hear, but it is actually ticking as well in stereo. So it's not just a dumb world. Objects in the world once they have been imported, come in with their characteristics – a bit of bedroom furniture here, it actually works.

So if we go back to this, how does it work, is that what you wanted? Yeh, basically we wanted to change the curtains here, we could go up and down the selection and here is a fabric swatch and below it are a pair of symbols, one which will load it onto the curtains in the room and the other will load the fabric onto the furniture. If we now click on the curtain icon over the internet, slowly but surely, it downloads the curtains straight into the room, like that, and it does it in this example for all the curtains in the room.

And then if this was a model of your own home, it would know the exact height of the curtains, the width of the window and it can do online calculations of, for that fabric, how much it would cost. If you like them, and you think you can make a judgement over this system you could place an order and pay for it over the system as well. And this will apply also if you pick this particular bit of fabric and put it onto the sofas, bang, now this is the system that is a year old.

And all the rendering is very, very crude, but nowadays, this year we have got a much better renderer and I can show you that later. Where we will see the lumps the bumps the cording, dents in the cushions everything shown on the - the other thing about it is that when you leave a website, we intend it such that you can leave behind samples, so in this area on the coffee table are samples left behind from a previous visit to another site and they are still active and they still know where they came from. And that will apply to light fittings, paints furniture, televisions, accessories, whatever they will each have a destination, a place they were loaded from and you will be able to get back to that from the model.

AC: If we are going through the questions as we did before and then we will come back and talk about that. If we just go through the questions as we did before and then if there is anything you want to add, prompt me, we can do that.

AC: So really to start off with it is the background and general aspects about the project. And the project would have a title, is that title?

KF: It started years ago, do you want the history of it, [**yep**] right we basically, we looked at doing Virtual Reality property over the internet as a service, and that was two years or more ago, and that turned into 'Propnet' which was not a Virtual Reality system but it was in fact an estate agency details on a searchable database. And that's launched as a product I think we have sold the rights for it to a publishing house. One of the aspects there was, we wanted to model virtual reality new houses and we got involved with various builders and we took the models from one builder and built them in this system and it became very clear that the houses we built were empty and they looked horrible so I thought I would put carpets and curtains just like you would for a show house and we found at that point that we could sell this as a service and that was when 3D retail was born, as an idea and that was I suppose about two years, eighteen months ago, something like that.

There was. I then built this demonstrator and got Superscape to get this piece here to work, so that when we loaded a texture over the internet it went straight into the world without any dialogue boxes anything that Microsoft would normally put in the way of downloading things direct over the internet.

And it the thing the way we did it was we got it to download and replace what was in the world. So you, the world wasn't growing as a file it was sustaining the same size, and we were just substituting. So if you logged off now you would be left with this new file created.

And once we got that to work over the internet on a prototype we had to have a robust version of it we also at that point got two companies interested, Laura Ashley, because I had been talking to them about using their fabrics in my demonstrator. And the other one came out of Innovation 97, when somebody saw it, which was Allied carpets, but they have a company which is called, they own a company which is called interactive colour solution.

Which have built a 2D version of this, not over the internet but a local one, which is beautiful pictures into which you can substitute the textures, and they were very interested in this as a web version of what they did.

There was then a major change in the rendering software about last august that enabled the Superscape plug-in to get much, much, much better pictures and I could show you a file which shows you the difference between what you see now and what the future is. Do you want to have a look at that, no? But that's where it came from, is that what you wanted?

AC: So that sketches out the historical path of the current project. How does that relate to other projects within BT?

KF: Basically, we were looking for internet services; this was an internet service, so its added value and it fitted into a program that's basically e-commerce. The thing we were trying to do here was, first of all get people to go to a website, 3D websites get visited. The second thing was we wanted large companies to put effectively their catalogues available over the internet so that people could buy things. And then in this we were able to produce a really interesting 'what if' catalogue where you could, instead of wandering around a virtual reality shop and just looking at curtains or whatever, you were able to load it into a model and add Laura Ashley curtains print and carpets, Dulux walls, real serious added value over the internet and that gave a lot of mileage to e-commerce. Because now we can talk about a virtual design environment on the internet where customers can play for free but it was real products.

AC: Do you know of any work that was going on outside BT that would relate to the project?

KF: Yes one thing is the new copy of 3D interior designer, which would be 3D interior designer3, or whatever they call it. Was looking to, when we went to see them about using their product to build our rooms, they were looking to make an internet version of it, so the two came together. We have also seen some badly done ones. From where, this uses standard models, well one of two standards and we have seen other systems where they have proprietary models, where you can go to Visual Home Delux's site and download a General Electric washing machine, but they have to be made by Visual Home Delux in a special format.

And what we're trying to say here is that we will make the format freely available to anybody and that there is a toolkit out there for less than a thousand pounds which will allow you to build your own. So any retailer can create, or manufacturer, models that would be compatible with our system. What were doing is looking to interface with those make money by hosting the sites. And what seems to be most important to the retailers and manufacturers, and they can't get this type of information any other way, is individually attributable buying habits, selection processes, who is looking at what when we can data mine that. That is the areas, any other associated projects, it ties in with all the BT technical stuff to do with data mining, commerce, web hosting, which we, this is a sort of catalyst project - it uses, and benefits from all those other systems.

AC: Would you say that the project is part of a larger investigation, or is this part of a bigger project?

KF: It didn't start off that way, no; I think it will be the other way around. There will be spin offs. This will become a massively large bit of business but it will use the same software ideas again, again and again so one different, it will use it in different ways. So you will be able to sell Sony televisions like this, you will be able to sell John Lewis's lighting department, do you know what I mean, it can be applied in multiple ways, even in education you can load down something and it will show you how to build it in Virtual Reality and model it.

AC: Ways of perhaps describing the justification. Does it fit within that list?

KF: It was a new product/service development.

AC: Right, predominantly or only?

KF: It was, we had to develop new services to utilise what we had got. And it wasn't to do with dissatisfaction with existing methods or solutions, but it has provided dissatisfaction, now that people have seen it, they like to use it, and they are not satisfied with just hanging up samples at a, a piece of carpet, they want to use this so there have been some very different reactions to it.

AC: It has created a new paradigm in that sense?

KF: Yes you couldn't do, a store couldn't show it's sofa in all 32 fabrics, but, unless it took a photograph of them or whatever, but this you can look at it in all 3,000 fabrics just by clicking, by getting the model of the sofa to wrap with the texture.

AC: Could you say something about the original objectives of the project?

KF: The original object was to get people to use a particular web site, anybody can create websites but getting people to visit them is extremely difficult, we found that 3D content attracts people to websites, the other thing about this thing is that you could do something fun and useful on the web site. And the third most important thing about it is that our system allows you to save the world you have created and run it when you are not even online. So you can save the file and you can mail it to your friends, email it to your friends, and they can play with it and see the room you have created or whatever. So its two or three features that the web doesn't already do I think, it can do in other ways, but this was I think a first.

AC: Were the project objectives specified at the beginning of the work?

KF: No, the only thing was to create a new service which would drive up demand for all the other things that BT can do host websites, mine websites charge for internet access. It was to drive all those other things, the fundamental thing that I felt and most of us designing services was to get people to look at them we've got loads of services only 10% of the population use.

AC: And is there a novelty to that which might wear off over time?

KF: Yes, the novelty will wear off, I think it's a bit like creating a video player, in that the novelty is good for the first few things but then after that it is dependent on the content. And I think the novelty will drive the 3D to begin with but what will keep it alive will be when real retailers put real content on and keep it up to date and they will start doing all sorts of things with this ability to move models and textures around and keep them and I think there are things we just cant dream of that they will be doing with it, you can add sounds as well.

AC: So the objectives were changed over time, were there any specific points when?

KF: The objective has always been to make a profitable service for BT. So the objective has been the same but how we achieved that and where we get extra revenue from has changed as we developed the project.

AC: If we talk a little bit about the timings, you said the project started about?

KF: Well it came out of another project two years ago.

AC: And what stage would you say the project is now within its timescales, currently?

KF: Well it was stuck for about nine months when nothing was done in those two years, because it was just demo-ed to death everywhere, yes, and there was no formal agreement to proceed to a trial was given, so for 9 months it was demonstrated to everybody who came through the door here, and to many of our major customers, and from that we derived a major insight into where we could do a trial, then the funding came through and we were able to move forward, but it came so late in the financial year that we had to go over one end of one year and into the next and we then had to go through the funding cycle again, so that put another delay in there.

AC: And that was the nine months in total?

KF: No nine months, followed by another two or three months, so it's really about eleven months to a year late if we had funded it from the word go. But in that time the market place has changed, to our benefit.

AC: And so where is it now in relation to where it will be?

KF: It is within weeks of going public on the internet as a closed user-group trial for two retailers, selected customers, so in about 6 weeks time it will go live on the internet being viewed by strangers, untrained strangers!

AC: Do you perceive there to be an end to the project, when would that be?

KF: Yes, my particular criteria for ending the project is when it gets adopted by part of BT, after the trial and being offered by a whole group of BT that just sells the service, and operates the service. And that could happen, adoption could happen any time within the next six months.

AC:\And would that represent a natural conclusion for the work?

KF: Yes. When somebody else claims ownership of it. That's the time when my job. Re-run as a service or killed they are both the same end.

AC: Why might it be killed?

KF: If when they run the business model after the trial they find that it is uneconomical to run it as a service. We have to run the trial to understand the technical implications and the costs to BT of running the service.

AC: They won't become clear for sometime?

KF: They don't come clear until you really hit it hard. Its this ten hundred thousand cost thing, the design takes a factor of one or something in cost, you run a trial it costs ten times as much, but to actually run a service is a different ball park. And it maybe costs a hundred to a thousand times as much as running a trial. And we are committed then to providing the service to customers.

AC: In relation to the project who would be the key people, in terms of management, planning people involved in the project?

KF: It's my baby and it nearly died a cot death [laughs]. And then it nearly died when it had its injections, you know so it's been my baby for a long time. The other people who were involved in it have not been involved technically or creatively. They have either been in the way of the funding really or actively pursuing funding for me. So the other people who are technically involved are Superscape, the people who's plug in we use, and CBL who wrote the 'Interior Design 2' software, who have written our web robust version of software for us.

AC: So they are creating software but they are not actually involved in the implementation or the making of the world?

KF: Yes they have been integrally, we put out a specification of what we wanted to do, for a certain amount of money and joint intellectual property, they didn't do this just for money, they wanted a piece of the action. They have created the latest software which was delivered a week ago, a fortnight ago.

AC: So the latest software part of it; that was developed outside of here?

KF: That was developed outside of here, but purely from our, we wrote the requirements, they were the company that wrote the software, for us, to meet those requirements. And also at the same time we have a patent which was applied for before we showed it to the public a year ago. So the patent is probably clear by now. It takes about a year to two years.

AC: I have a bit that talks about patents as well.

KF: O' right.

AC: So there is yourself really?

KF: And other contributors who have joined it in the last three months are, Mary Jones, when we came down to some really hard user interface issues, like the target market for this are computer naive women, I don't mean that in any other sense. And that is not the normal market for internet pages.

AC: And Mary's expertise is?

KF: Human psychology, I think, user requirements gathering, defining what the user interface should be and how it should look and feel, and work.

AC: And she is going to be involved in that?

KF: Her involvement is practically over now she did a survey of, it has always been part of the project, until you got funding you couldn't do it. But it was to actually go away from me, totally disconnect it, and look at how people purchase home decoration. And so there is a report about it available now, she has just sent it to me. To influence what we were doing by the real way that people did things. So she did a qualitative research, of ten people, but in depth actually in the process of doing purchasing home decorations, curtains, carpets and they were selected by an agency, nothing to do with BT and she spent a day with each one of them - in the process.

AC: And was that looking at that at how they currently doing it or how they would do it using the software?

KF: Didn't mention the software at all, we wanted [to know how they] currently do it. We aren't trying to invent new ways of shopping, we are trying to facilitate what they want to achieve over the internet.

AC: And if we talk a little bit still whilst we are looking at the background of it, in terms of the project...

KF: There is one other person, sorry. Rather important, one of the other key issues that came about was that we had to have database management here. And we had to have a client and server architecture, for the trial, we couldn't just have a few files on a server, we had to do it properly and John Whittaker, who is on the ecommerce team. He sorted all of that out with CBL. So that the software we bought really talked over the real World Wide Web to a client server mode, and that was very important. He has got that right in the last two months, and that was key to making the whole thing scalable to a real product.

AC: And his aspect was to do with the delivery of that?

KF: Delivery of the service over the internet in an internet efficient way, and a scalable product, so if this trial works. We just scale the thing up to thousands of users.

AC: And his background is?

KF: Software, it's actually in materials research but he changed jobs a few years ago into software engineering on the internet.

AC: There is another quote which I haven't read. Which is to do with any collaborators on the project?

KF: We collaborated with CBL, Computer Based Learning, in Derby, who wrote the software for Europress the publishers and I would say its collaboration. We have also collaborated with Superscape who provided the plug in. And now that the trial is running we are getting considerable pressure from Intel to collaborate with them because this really hammers processors if you want to make it better and better. And they want to use it as an example system that they can demonstrate their processes on.

AC: So they can test the limits of their processors?

KF: This is why you will need an Intel 400. It's not true at the moment, basically the rendering does, if you move through a room it would do one frame here and one there. If you add an Intel 400 processor it would add lots of frames in between and therefore it just smoothes out the journeys around the rooms, allows greater amount of detail.

AC: In relation to the amount of information that is available, I have got a file on 3D retail. Is the stuff that you have got here is that on the internet?

KF: No, the trial is and that is sealed up like a drum.

AC: Is that within BT site?

KF: No, it's just a locked site so we can open it. It is on a public server but locked up. Rather than being inside a firewall. It's outside the firewall, but it's locked away.

AC: But presumably that is something which I could access?

KF: Yes, this demo you could have as a standalone on your machine. The new demo which came in a fortnight ago, which we can have a look at on another machine. That is on the internet and a client software is available to be downloaded over the internet. It has its own web site but it's locked off to the outside world.

AC: Is there anything that has been written about it, not it itself but on the internet?

KF: Yes there was, but it has been taken off. It was on, a year ago, on the Innovation '97 website. I have the content of that, but it was there for over a year.

[phone interruption]

AC: There was information on the Innovation '97 website and you have got a copy of that information. There is nothing else that is contained on the internet that you know of, relating to it?

AC: Is there anything on video about it at all?

KF: Yes, I have got several clips it's been on television about three or four times. And I have got the actual clips, Sky and Channel 4.

AC: It would be good if I could get a copy of them.

KF: I have got all of them, a compilation.

AC: Is there any physical imagery of the interface in any sense storyboards or renderings?

KF: Only the ones I have printed off. There are loads of copies of this demo on lots of machines, this old demo, like it's on the standard BT demos at exhibitions now so there is a standard piece of kits. And several of the account managers I have loaded copies on.

It's also on some PCs at Natwest's demonstration area, Natwest Bank's demonstration area, called Catalyst which is in 41 Lothbury which is behind the bank of England. They run lots of, it's a joint project between Natwest and loads of companies. And it's actually on a PC there, a specialised version for sort of futures version of it.

AC: Did they use that?

KF: I believe so. It's not going to be running very long the exhibition. Its on there, I loaded it on and did a special front end.

AC: And that is an exhibition?

KF: Is sort of invited guests run through it, its quite a performance to go through the system, its got loads of technology done in a sort of pseudo futuristic way.

AC: Were any three dimensional mock ups made of the interface?

KF: No, it's all lived virtually inside files. Other than it being a real room and real fabrics.

AC: Other than it coming from your lounge originally.

KF: Exactly, that one, the others that we are building, rooms, are purely out of the heads of people at Laura Ashley, the Georgian room or whatever.

AC: And had there been external review, in the sense of things like published papers?

KF: There is an article in competitive edge which is an internal magazine that leaks outside, back in August last year, there. And that has got a lot of good stuff about it.

AC: Nothing at thing like CHI or HCI events?

KF: We kept it all away from that lot mainly because we didn't want anybody copying it. There is nothing earth shattering about the user interface.

AC: But commercially?

KF: Commercially it is about web site traffic, web site attracting people to web sites.

AC: Do have any newspaper clippings, or any articles..?

KF: Yes, there was a very interesting article in the retail press and the actual journalist took two and two, added them together and got 36, unfortunately he got all 36 points right. So he understood who.. and then he went and found out that it was Laura Ashley and said to Laura Ashley that BT had told me and they told him everything. And then he found out it was Allied carpets and said that Allied carpets and he got all sorts of information and published it and we got crucified

AC: In what sense Crucified?

KF: Well letting it all out, but we didn't we thought each other was talking to the other but it wasn't it was the journalist, who was adding two and two together, and he was very good.

AC: Do you have a copy of that article?

KF: Yes, there was very red faces. 'I thought you told him, no did you'. It was, it's a hot topic, I think it's a bit passé at the moment, but when it's actually out there and working it will become a hot topic again.

There was some mention today that B&Q seem to have copied it, so we have got to go and find out what it is about. We are not worried about that really, because its not 'it' that we are worried about being copied. It's where they do it and how they do it, not the fact that somebody is trying to do it over the internet.

AC: So it's not like trying to own html, it's like trying to deliver a service?

KF: Yes, we want to make a service, and if they have done it, it is a serious form of flattery, but I think we have got a system that works efficiently. And maybe B&Q would like to use it. And we will use theirs if theirs works better.

AC: To a certain extent if other people are trying to do it then it suggests that there is something in it as well. Have you done any other interviews relating to it to external people?

KF: Not interviews as such, no.

AC: You have demoed it.

KF: Hundreds, hundreds of times, literally.

AC: Are there any other data sources that you can think of that might relate to it?

KF: Where it is leaked out or where it could be referred to?

AC: Where it might have been referred or either internally BT or externally?

KF: I know there are memos going round inside Marks and Spencers about it, because people in Marks and Spencers said they had seen it. Other than that I imagine that each of the companies which have seen it might have talked about it internally. But no evidence of that one.

AC: Has anybody outside made any particular evaluations on it or critical analysis of it?

KF: They have never had it, nobody outside has had a copy of the demo. There has been a version of it, put on, not my version, but Superscape had it on their site a similar thing that they did and it is available to be seen. It has one crucial difference. Basically, they load a file with all the textures in and then you switch them locally and it works very well, and I would be interested to see what reaction had from that.

What ours does is dynamically loads the textures from any site into the world. Rather than load the world with twenty textures in it you just switch between the textures. That's the difference, do you see what I mean? So we could be in a world and load textures from MIT labs, followed by the next texture comes from IKEA and the next one furniture comes from John Lewis's. Whereas the way the Superscape on did on their virtual world wide web, you can still find it on their Virtual world wide web (vwww.com), what that does was load a file with lots of textures in it and you just switch the ones on the wall, the ones on the carpet, the ones on the sofa. But they don't come individually from different places they all come with the same file.

AC: So, in a way the site that you have is like referencing and image in html, you can just link to anywhere?

KF: Well it doesn't have a reference in the original file. The actual catalogue bit here, is built up dynamically from the website you are looking at. This model is held locally the two are divorced. And as long as when you press this one and there is a world there that can accept it, because of standards, it will load that into there. That is not the same as custom building those two together and not being able to do it from any other sites. That's a fundamental difference.

AC: That's the patent, therefore?

KF: Yes, that's where we have tried to patent.

AC: Ok, if we talk a little bit about the actual design interface. Did this particular interface have a brief attached to it?

KF: No, I spent a long time with a couple of students trying to work out how on earth we would produce a demonstrator. Claire Bryley and another student, they were ones who came for a few weeks here. And I had my own ideas, and I tried to write a brief for them to do it and they came up with lots of ideas and then eventually I came up with this way of doing it. I don't think there was a precedent, any other way of doing it, really. I am sure there is now but there wasn't then.

AC: So in terms of the interface, what is the actual purpose of the interface?

KF: The purpose of the interface is to enable very simply a selection of a particular texture or of an object and have it placed automatically in a world in another window. So effectively the whole purpose is to be able to load over the internet. This window here could be customised to every single retailer or manufacturer, but we were trying to work out, the fact that it could have the same brake clutch and accelerator. Used on the page to drive it even though it would look completely different, it would always work the same. So like cars are all different this would be different relative to the brand, but it would still have a steering wheel, a brake clutch and accelerator and it would still work with this world

AC: Would that be visible or would that be underlying code?

KF: It would be visible in the sense that there would be buttons icons on here that were consistent between brands but the actual look and feel would, may be tailored to each brand.

AC: So things like where you click?

KF: Would be the same. In fact, I can show you the interface on another machine of where we got to in the last fortnight, that's much further ahead. That has the ability to click on a curtain, no on a fabric, and drag it on to individual curtains on to individual objects, if you are dragging in a sofa that's here, instead of a fabric, when you drag it across, this goes from a 3D view to a plan view and you drop it on the plan and all sorts of things like that, much more sophisticated. But the actual look.

AC: If we just talk about the software to begin with here. What software was actually used to build the virtual world?

KF: Right first of all we have got, scanned in. To build the world we used Superscape's VRT, software, virtual reality toolkit, and I used version 5. I then used, that was before another product came out, there is a new version called webmaster which is purely web based version of VRT, that has come out since. Which would have made that world a hundred times easier to build; I built that world facet by facet.

AC: So you are anticipating my next question. Does the version 5 express the state-of-the-art software, it did at the time?

KF: It did at the time, its 5.5 now, its far, far easier to use. Webmaster is the cheaper version of VRT 5 and that is extremely powerful and I could have built it in a tenth of the time, easily.

AC: Has the Superscape software changed considerably over time?

KF: Yes, I have used it for five or six years, when it was DOS based command line stuff. And it is now full Windows 95 graphical user interface with drop down menus. There is just no difference, there is just no perceivable connection between the two, it has been a natural progression.

AC: Do you expect that to change considerably in the future?

KF: Yes, yes. Very soon it will generate both VRT and VRML files at the same time so any standards issues that there may currently be this month will disappear.

AC: In a sense it won't matter which software it will just created in?

KF: No, it won't run on a Macintosh ever. Well the new ones are very, very powerful but they are able to emulate Pentiums. So we can do an emulation in the future.

AC: Not many of the virtual worlds will work on a Mac?

KF: No, not that I know of. We used to run our VRML stuff here, VRML 1, on a Mac but they were too slow, one frame a week, you know.

AC: What was the actual justification for using the Superscape software for building the virtual world?

KF: Basically, one person on the project and my own, I am not a 'C' programmer, this is the type of toolkit a designer can use. And I went away on the courses and when it was dos based I used to have a refresher every year. Now that it is windows and GUI based it is fun to use.

AC: Do you think the software has constrained the development of ideas or facilitated the concept?

KF: Both, it has constrained some of the things I wanted to do. But now the software has added features which I haven't even got my head around, things like fogging. I really haven't got into distancing, levels of detail, very heavily yet. And I haven't come to the limits of its texture ability, I really haven't, I have been trying to produce a service that works over the internet. I haven't had to time to blast the software I don't need to hammer the software to get what I need. I haven't met its limits yet, not all of its limits.

AC: What areas do you think it has constrained the design solutions?

KF: In the past?

AC: Currently.

KF: The palate, currently where it is on 256 colours which are all dynamically allocated you have to work out how you are going to allocate a palate during a flight in a world whereas if it ran on 16 million colours which its moving towards in the next few weeks. It will eat up processor power but it will give you a tremendous flexibility.

AC: And you mention you haven't found the limits of the texture or?

KF: That was its limit before and I haven't reached that limit since the software changed.

AC: And, you mention fogging and distancing is there any other aspects which have facilitated creativity in the design?

KF: Sound, sound editor, its foregrounds and backgrounds, I really haven't utilised those at all. It has the concept of a world on a stage so it has a pro-senior march and it has a background with a world in and a stage in between and I only use it in a mode where I am looking at what's on the stage I don't use backgrounds very much I don't use foregrounds or controls at all, I could but I haven't yet.

AC: Do you think that the result that you have has been shaped very much by the software?

KF: It's better than I thought I was going to get out of it. Is that an answer? It's getting better.

AC: In a sense that it hasn't held you back?

KF: It made me do things economically, but being economical with the virtual world design has made it very fast and therefore it does other things that I didn't think it could do.

AC: You mentioned Webmaster, the other software, how would that have changed the design?

KF: It has a different way of rendering, it has, the total concept of being clipart, so clip objects, so instead of building a room there are lots of rooms already built that you would just copy and modify. Whereas the way I built mine was here's one facet which is a window pane and I built window frames around it, there was very little clipart clip objects available. Now there are thousands of them pre-built objects.

AC: Do you think that had you used the other software you would have got a very different solution?

KF: No, just got it an awful lot quicker. A lot, lot quicker.

AC: In terms of actually delivering the service, would the software to deliver it be different from that which you made it in?

KF: Yes, you would just need a player and it is called Viscape and it is free.

AC: Does it actually have different characteristics?

KF: You can't build it in it you can only view and interact with the worlds we've got around that a little bit with what were doing. We can actually build and we have modified the interface to it such that we can load things over the internet, put them in the world and keep them and save them. But we haven't got all the ability to build a table, you have just got to load a table.

AC: And is VISCAPE got different software version?

KF: O' yes, there's an NT version, a 95 version, I believe you can get something to run on a UNIX box as well.

AC: And which one would be the optimum?

KF: Whichever. The machine is 95, this was where they develop it first so the next release always comes out in 95.

AC: Does that express the state-of-the-art use for that software?

KF: Yes, they have made visualisers for silicon graphics machines; they are very, very expensive. You know a Viscape for an SG machine but the whole point of this is that you want to send things over the net so they have got to be very small and efficient. And giving a small and efficient file to a silicon graphics is a bit like giving a donkey a note.

AC: And also presumably that would limit the amount of people who could use it as well?

KF: 0.001 percent yes.

AC: Do you think that Viscape will change considerably?

KF: Yes, I think it will actually disappear, I think what will happen is it will become a standard function of your browser so it won't be seen as a separate player it will just be one of the file formats that your browser can run, like it can open word files or whatever. It will just be able to open Viscape files or Superscape files or VRML files it will become invisible. No it will just be preloaded.

AC: Was the means of delivery identified at a particular time in the project?

KF: At the very, very beginning because I believed from my knowledge of working on VR with Superscape that I could do what I wanted to with the Superscape software. Whereas I couldn't do it with the VRML software. I am sure I could if I could have written c++ but with my own design skills I couldn't do it.

AC: In terms of delivering the idea does Viscape represent the ideal solution?

KF: No.

AC: What would be an ideal choice?

KF: A Silicon Graphics rendering machine for £200. But that's where the project is going, and in fact today Sega have launched their 128bit machine with a network connection running windows. With a special 3D. What I think what has happened is that the games market has dried up for the hardware producers so they are attacking the PC market, with fantastically powerful rendering engines audio engines for peanuts.

AC: Do you think it will all be absorbed in digital television?

KF: I think the other way around, I think people will think of it as something which plays television as well. Like your hi fi plays all sorts of formats, television will just be one of the formats that is coming through the screen.

AC: Do you envisage that on a computer hardware?

KF: I think that the computer for the mass market will disappear, you know, we were talking at lunchtime about how long it takes to get this program up on this machine, and that is ridiculous, it should be able to just pull it up. Why is it doing that, because it has a processor running dos onto which you put Windows '95 or whatever, well it doesn't it does something different, and then it opens up a browser and then it opens up a plug-in, then it opens up…its wrong. What the person wants to do is what the end result is, so you design a machine to deliver that end result. If that end result is a television view browser then you deliver it, Bang, every time, you don't go through all the other processes and I think that is what is so efficient of these games machines, they are designed to do nothing but what that is all we have got to do is instead of the content CD be an application, we don't need windows really, pull up banking instead of grand prix racing, that's the way I see it.

AC: That's certainly answered the next question to do with hardware and alternative hardware.

KF: I don't think it will be the only hardware, I think where this application will be run can be run on shops on effectively a glorified till, so one that the customer can play with, you know, and the other one would be touch point terminals.

AC: Multimedia kiosks?

KF: Yes.

AC: Do you think that the hardware we have got currently has constrained the design?

KF: Of this software, yes, because it's running on Windows within it.

AC: Are there any examples where it might have facilitated the development of concepts?

KF: The fact that this particular plug in can run as an active x component means that we can in fact take these worlds and run them inside word documents and that has fantastic potential and we haven't exploited that yet. Other than on the Muesli trial.

AC: What does that relate to?

KF: That's where they took my content and got it voice driven with an intelligent agent behind it. 'Show me all the yellow curtains' and it auto sorts the database, and then produces a list of all the yellow ones from a voice recognition system. 'Put the yellow trellis on the curtains' and it picks the yellow trellis and puts it on the curtains. And they did that the first time and it was a wizard of oz. And they have trialled it with the real public already.

AC: Who is involved in that?

KF: Peter Wyard, and then Celia Miller on the human side of it and Phil Clarke on the coding side. Peter Wyard is from the voice recognition and natural language group that had to say, when you say put 'it' on the curtains it had to know what 'it' was, it being the last thing you found or whatever, so there is twenty times more work to work out the voice recognition than it was to put... but they needed a subject matter that people would play with. And so they used my content and my demo as an active x component being driven by a mega voice recognition system and artificial language.

AC: So that has kind of splintered off from the main?

KF: Yes. What came back was tremendous reaction by people wanting to do the process. But forget the voice recognition, 'let me get on with it just stick it on' why wait for the machine.

AC: They wanted to just use a mouse to interface with it?

KF: They just wanted to use it, the fact that this thing was taking ages to think about what you said before it gave you the curtains got them a bit upset. They also had an agent that would talk to you through an artificial talking head, on the same screen, 'would you like green curtains now', and it got some very wry comments, because it was trying to lead you down fixed paths. And an automatic bleeper for what the customers were saying, bleep, bleep. Machine.

AC: So in terms of the actual visualisations that you have this is one, how many others are there?

KF: If I was demonstrating to a potential customer I would show them three.

AC: Three different ones or?

KF: Yes, because this would be I would say a year old and I would then show them a world which is not on the web which, I can shut that down and show. Do you want to have a look?

[TAPE BREAK]

KF: These were the toolkits, I'd show them how the worlds have changed from the demo you have just seen.

AC: So it's still three discrete versions?

KF: It's a very slow machine, I wouldn't normally demo on this machine at all, but I use this 120 machine just to make sure that when, somebody with a 120 machine, I know what it is capable of. I usually use my 233 portable to develop the new worlds on anyway. But this shows you how slow, this is the webmaster software, shall we zoom in on it? It's very tedious, what I am going to show is a world which has three sofas in it, and there was a year between when one sofa was made and the third one. And they show how the software has changed and enabled us to do better products.

AC: Is the final sofa current, the contemporary sofa?

KF: The sofa that we are showing, the final one of these three is actually modelled on a Laura Ashley Cambridge sofa. I don't know what has happened here. Normally it is the one the desktop [laughs]. So what we have got here this is the sofa from the original demo, after six months, and this is the texture that you had to send across the internet to get you that. I then improved the sofa in its modelling but then I had to send across for every sofa a different set of textures, these ones, to give you this model here. And this is what has happened with the new renderer, that is the same model but using the new renderer, and you can see that the quality of the image has improved immensely. And this tiny texture here is all that I need now to send over the internet to give me that quality of image. So what has happened is that I am now able to send a single repeat of the pattern over the internet and it will automatically wrap it, and the new renderer allows these objects here, I have just highlighted, are in fact lights, so with this I can change the light, and you probably can't see it but I can change the light on the sofa dynamically inside the browser.

AC: So is that something that you do when you create a world or is that something you could potentially do once you have got...

KF: Once you import a lamp. It would light in the corner where a lamp is and you could change the daytime. And that is the difference between that and what we did originally.

AC: What would be the dates of each of those versions?

KF: That was August last year and that was the April of last year.

AC: That quickly?

KF: Yes, and I imagine that you will not see that kind of jump for another two or three years. The Nintendo machine might do that the Sega machine would do that kind of jump. But for us that gives us a much more acceptable product there and a tiny little texture to send over the internet which sped the whole of my thing up. I knew it was coming, I wasn't innocent, I was made aware that it was coming. Ok, and then the other world I normally show after that, if I can find it, is a world that absolutely saturates the visualiser and that's a world that I did, Laura Ashley had some requirements last April and what I did was I built everything they ever asked for in that room, and that just about saturates the browser. You have got to bear in mind that this file is about 15 mega bytes, virtual reality file, whereas the type that we would be sending over the internet would be 200k.

AC: And the previous one that we have seen what sort of size was that?

KF: 200kb.

AC: This is just really looking at the limits?

KF: What we have here are curtains that are actually rendering. You know we have got really good shadowing, moving fires, we've got very heavily high quality pictures on there, all the shading, its dynamically wrapping textures round curtains, and working out the shading live.

AC: Is this created in Viscape or Webmaster?

KF: In webmaster, it was created in webmaster, and I took it to the absolute limit, it has things like, light shadow and fly out and spin round, its got degrees of transparency. All sorts of difficult things.

AC: Degrees of transparency relates to?

KF: The actual palate of the world is 256 colours but to get the shading and the transparency is using all 16 million outside of the renderer to give you shades of grey, tones of things. Those tones across that curtain, you know. There are certain, loads and loads of greys being used to get the subtlety and that comes from the rendering not from the original file.

AC: Does this particular version change all of the sofa covers and colours?

KF: It, I've just got one or two buttons here I press, to change the floor, and I was showing then I could put anything on the curtains pictures or whatever. That's not what it was done it was done to saturate the system. I have another file that I did for Unilever which saturates the system.

AC: This particular one was done did you say August?

KF: No it was before August, June-July.

AC: It represents state-of-the-art for that time, would that be different now?

KF: No, August is when the product was launched, June July I built it. And it was then able to be, it couldn't be rendered in the previous version, but it can. I built it and then couldn't render it and a new renderer came that was able to render it.

AC: So how long do you think we have until the next big release?

KF: That will be the universal system and that will be about a month away. But they said that three months ago.

AC: So it's a matter of months not years?

KF: O' yeh. I know why it is delayed, it's because they have done a product which uses it for Lego on the internet and when that's out they will release the universal system for the rest of us to use. But they are keeping it exclusive while they are doing this work for Lego.

AC: The three different versions that you described, is here a fourth one that is?

KF: Being developed, yes. And that is the, I have to show it on the other machine. Did you see that when you changed the renderer you had to change the plug in inside the web tool, the web browser? It doesn't like having one version in Netscape and another in Internet Explorer. So I have only loaded that new renderer onto my portable and I run it locally but it can be run over the internet now. It's still flaky you can have a look at it.

AC: If we have a look at it just at the end.
AC: Which concept or version represents the most advance solution in terms of these things: Usability/challenging conventions/commercial viability or perhaps some other criteria.

KF: The first version, alpha one, of the new one, its usability is a bit flaky. The new version has been downloaded to the server today, and I will be having a look at it on Monday, when it's checked out, the usability of that will be really much better than I have shown you.
It's a commercial product.

AC: How would you characterise the different interfaces?

KF: That one does nothing apart from give you a concept of functionality, right, you can do this, you could do this you could do that, you could do the other, is what my demo did – that's the actual 3D retail demo, there is only the one. And then the actual 3D retail trial software, the client software, is in Alpha one and alpha two, alpha one I have got on this machine is flaky and the usability is a bit grotty and we've improved that over the last fortnight and alpha two is on the server now so I have got to down load it.

AC: And which one would you say challenges the most conventions out of all of them.

KF: I hope it doesn't challenge any conventions I want it to be intuitive to the user, totally, the technology has got to be invisible. We are not selling the technology; we are selling the fun, the ease of use, the invisibleness of what is going on. It's only the nerds who realise how incredibly difficult it was a few months ago to do what we are doing now. But the customer couldn't care less, the consumer, I hate that word. I mean the person who wants to do it shouldn't see the technology at all. The challenge, which dawns on people, is that most virtual reality shopping up until now, had been people wandering around virtual shops, its not what we are doing here is bringing the shop contents to the user and let them add them all together in their own room or in chosen room. And that a very, very different shopping paradigm than there has ever been put up I think. That's what strikes people.

AC: So it is based on need and requirement rather than...

KF: I want blue curtains with a green carpet. And there is no other way of doing it, you could go to lots of VR shops and find a carpet, lots of VR shops, or internet shops not VR, and find curtains but you couldn't put the two together in a model of your own room. I think that is fundamentally different and it is so fundamentally different that people don't even see the difference. It's so intuitive.

AC: It becomes obvious?

KF: It does, I want to see it in a room. Do the curtains open 'yes', it is natural. Yes.

AC: Shall we go back to the first interface if we use the one that we had before? What I will do is run through a few of the questions another day with the latest one. But as we have started with this one we should continue.

KF: This is the slower machine.

AC: This particular interface do you have a title for it, even colloquially rather than formally?

KF: I call it Laurence fabrics, it got called Laura Ashley fabrics and then they refused to let the brand be used at a demonstration because they didn't agree with the design of the room. Their rooms with their brand do not have televisions, radiators lights, in them, ceiling lights, they have up lighters or wall lights. They don't have any radiators they don't have any technology in them. It's their brand values. It would have all Laura Ashley pieces in it, in didn't, so they wouldn't let me use the brand. We changed it to Laurence Fabrics.

AC: Is this interface an example of something which is ongoing or which is finished?

KF: Finished, that was a demo to get across the idea. It taught us an awful lot and it stopped. It did set the precedent of the four windows. And we have maintained that in the next one.

AC: In the actual interface, I have got a list of things here, does it contain 2D images?

KF: Yes

AC: In terms of the swabs of fabric there is textual information is there numerical?

KF: There would be in the final thing, it does a calculator to work out how many yards of fabric you want, things like that.

AC: And there is a three dimensional aspect.

KF: All three mixed together.

AC: And how would you characterise the three dimensional from the rest?

KF: It doesn't become obvious until it moves. So it just looks like a 2D picture until you actually either move, because you can set an animation path, like this, or you want to interact with it. And in fact it becomes very powerful for 3D when you start adding sound. The curtains 'swoosh' rustle

AC: So sound is one of the key aspects?

KF: Key aspects to making this alter that, well with the interaction, the ability to move around is just phenomenal when you go from being stationary to a moving picture. And then you go to a picture you can really fly around and play with the doors and cupboards and things. So there are stages of interactivity.

AC: But that is the key difference I suppose between that and.

KF: It makes peoples jaws drop when they realise it is a web page and that it is not a picture. It brings it to life when it starts doing things with it. You start, you know, you lean on something and the curtains work, click on the hi fi and the hi fi works, you know, so it is not a picture, it is a real object.

AC: OK, in this sense does the 3d exist within a 2d metaphor?

KF: Yes it does [laughs] it is a 3D within a 2D metaphor, this is all 3D isn't it its windows.

AC: So the main representation is actually 2D through which you look at 3D.

KF: You have got a little bit of flexibility, here in that; you can make the 3D take over. And in fact in the new system that would be at the push of a button. You can remove all of the 2D and turn the machine over to render in 3D. So that when you have done a room, by selecting, you can put it full screen fly around and see what it is like.

AC: Was there a reason why you didn't put the 2d things inside the 3d world?

KF: Yes, software, I can represent things quicker, better in 2D here, than I could, that was that carpet sample. And text inside that 3D world is very badly rendered. The other thing is that I would have to load it into this file so all of this information would slow the file down. The size of that file would increase.

AC: Is that limitation based on Technology as it currently is, or on usability?

KF: Technology as it currently is. Also you can log off that site and go onto another one and this stays the same so they have got to be kept as disparate objects.

AC: So to maintain the illusion of that space just being a separate entity from the places you are going to look for things it has to be..

KF: I never went that deep it naturally came out that way. I couldn't get that to work in the, well I could in the very, very first demonstrator, I had little buttons along the bottom of this world and that didn't work that well.

AC: In one way you have the swabs of carpets...

KF: Carpets, but they are preloaded and kept in this demonstrator, they aren't being referred to. There is nothing to stop that working in place of this. But that's so much quicker to get down over the net than filling this up with real textures it takes a lot longer.

AC: How do you think that affects the usability of it?

KF: I think it makes it much easier to select in 2D and then apply to the 3D world, and Mary's got evidence of that from the work that she did.

AC: In what ways was the 2D better?

KF: Speed, it's also a familiar. It is bad enough trying to get people to fly around but to pick objects and to place objects in a 3D world is much more difficult to do it in a 2D world.

AC: In what ways is the 3D world better?

KF: In the fact, the juxtaposition of things, you will be able to change your view of the curtains, a sofa, and a carpet. You will be able to go behind a sofa and look towards the door, you will be able to take in things you know, you are doing effectively 15 frames a second or whatever. And your viewpoint is just infinite and the interactivity. You know you can sit under the table or whatever. Sit on the sofa that's where the 3D really starts working. The other thing that we found immediately was a lot of people can't understand what, how big a pattern or how horrible a pattern can look. You know, what does that sofa look like with this pattern on, you know how horrendous would it look. And they couldn't judge putting a sample onto a real object, so the scaling. And some of these can cause real problems – like when we put this one on you know, it really is a horrible sofa. And that's what some people end up with, as a problem don't they?

AC: Also with wall paper and everything.

KF: Yes, and we can do all of that in the new system, will do wallpapers, dado rails, everything.

AC: Ok, can users change information in that space, what sort of level of?

KF: They can refer to other sites; they can't draw their own patterns, not yet.

AC: Potential?

KF: There is no point unless you can reproduce it as a wallpaper. That could be a potential product area in the future, design your own wallpaper.

AC: When they actually, interact with it would you say they have a high level of control or a low level control?

KF: They have got more control than they have got in the current real shopping. So when you walk into a shop and you see wallpaper you can't instantly see what it looks like in your room. You can only hang a piece up on the wall. Whereas this, if you used it in a shop or at home, you could actually see the wallpaper all over. On the sofa, so I think that they have a higher degree of control than real shopping, much higher.

AC: How interactive would you say that the interface is?

KF: Completely, we hoped to have it so that anything in there does what that object does. So the curtains will open and shut, the cupboards will open and shut, the television could have pictures on it if the PC was powerful enough. And so it will be tremendously interactive and intuitive that's what's most important rather than interactive. It's intuitive of how you get that fabric onto there. And that's the difficult bit.

AC: Would the interface ever be immersive or is it just 2D?

KF: It was never envisaged when you start mixing 2D and 3D and putting them into a helmet.

AC: It doesn't work?

KF: I don't know, it might be something worth researching.

APPENDIX 4: RAW DATA STRUCTURED TO QUESTIONS

An example of the raw data selectively structured to the interview questions after the initial write up for Call Waiting. Italics are the original questions as listed in Appendix 2, followed by the actual question presented and the answer given.

Main Analysis technique Breakdown - Summary Findings

Findings

133) What do you perceive to be the main successes of the project?

KF: "one is that it was used totally out of proportion to the amount of time that it took to create it. That it led on to Amanda's work, and Amanda's work did change the way that telephones were laid out, to reduce confusion for customers, that was a spin off. The other one was that it made people think a whole lot more about what we could do with a screen phone, because up to that point they had been duplicating in text on a screen phone and the first ADSI screen-phones were all text phones which weren't addressing the problem. And I believe it was one of many projects that pushed people, many projects, pushed people towards a graphical 3D way of using services rather than text based way of. So, it was like trying to get a GUI onto a phone. It was one of the things that helped push a GUI onto a phone."

AC: And a GUI is?

KF: Graphical based user interface instead of a text based user interface.

134) What do you perceive to be the main shortcomings of the project?

"It didn't get an owner, in the business where it could have had an effect. And the reason was that wasn't the aim of it initially, but for the company to benefit from it, it needed to have an owner other than just as a research demo."

135) Were any guidelines discovered through the project?

KF: No, I think it is a very closely knit field that we are working in, people who could influence saw it, that's all you could say, there's lots of people who know it and that was all it was supposed to do. It hasn't been built into any guidelines. It has put a spin on, I hope, it has just put a spin on the way you look at things, does it the way you look at things? I mean that's what the icons did it put a different spin on the way you look at things.

AC: That leads things forward the thinking of the group?

KF: Or, they don't like it, I, the thing that Amanda wanted to do was completely different which I think was great. But, because before there wasn't anything, now there was one, now you could build something better and different from it but before that, call waiting, there wasn't anything not that I know of.

136) What were the advantages of using 3D?

AC: What would you say the main advantages of a three dimensional were?

KF: Speed, I could generate an animated sequence in seconds by giving something bounce, you try and do that with a set of cells, you know, and I could vary the rate of the bounce so the 3D world was, the other thing was that I could set my viewpoint whenever I wanted if I couldn't see all of the elements that I had built together I could readjust the viewpoint. This was for setting this as an animation we were not using 3D other than as an animation package in this case.

AC: The alternative animating software would be?

KF: A nightmare. It was cell by cell rendering of each cell on a PC probably as wire frame with flat colour, so that's what was around then if you wanted to go to anything more than that then you would go off a PC and you would go onto a mainframe or a silicon graphics and they needed acres of training to get on it. It could be done we had the ability and the skilled people, but this project wouldn't have justified it, it was more important to put that skill onto something different.

AC: And do you think that the advantages?

KF: They are general advantages for visualisation, if you can get visualisation straight out of the person having the idea, rather than via a technician be they a programmer or whatever. Then you can give the creator of the idea the tool and then the other thing you can do is take the time between the idea and the creation, shorten that so instead of having to carve something its there instantly then that's the other advantage. Because then you can then Change and change and change and that's what I found was lovely about doing it and I think that's what keeps you going the tool was non tiring, and highly creative.

137) Do you think these were these specifically related to this project or more general findings?

138) What were the disadvantages of using 3D?

AC: What were the disadvantages of using 3D?

KF: The user interface was rubbish, and you as a designer wanted to spend your time redesigning to the interface. And what was really funny was I was trying to design easy to use interfaces on a tool that had a terrible interface, it was a certain irony that the tool was appalling bad laid out but had the functionality that I wanted. That was the frustration.
It wasn't consistent was the upsetting thing, I don't mind it being bad or difficult to learn but when the thing wasn't consistent in its abuse, when it got things wrong it got them differently. You were 90 percent of the way there and then it didn't work.

AC: Do you think that...

KF: The tools have improved, out of all proportions.

Main Analysis technique Breakdown – Background and Project Context

<u>Background and Project Contextalisation</u>

Q1&2. General Description

1) What is the project title? **AC: If you were to characterise this as a title would that be Call Waiting?**	 KF: Yes... no, it would be service creation tool improvements.
2) Is there a history to this title? **AC: Is that how it was known at that time?**	 KF: It was known by a number, because it was such a large project they had loads of different, 9146 or something and everyone know what 9146 was because it had such a large budget. And Call Waiting was just a tiny, I think 40ks worth of work to it, no 17/18K worth of work, and I was given it at the end of the year to come up with a demo that we could show at a final presentation of the project, that was the work.

Q3&4. Relation of work to others - historically / currently

History: 3) What is the relationship of this project to key historical projects: **AC: If we start with the background to the project and then what I will do is ask a few questions relating to that and we'll take it really casually so its not massively structured but these are the guides about what I will ask. So the first thing I have here is, if you can cast your mind back to the history of the Call Waiting case study, the first thing is, How it related to other projects historically before Call Waiting: so if there were projects that fed into it and what they might be and what relationship they might have?**	*3a) Within BT (human factors)?* **AC: So, was there other work that was going on within BT that related to it service creation?** KF: A fantastic amount, I mean the actual specification for this service creation tool is, it was like a telephone directory, you know, *that* much information; and that was partly the reason why we didn't try and build a new tool to do that job, what we did was we looked at modelling the end result and from that in Call Waiting we ended up with particular pieces in the model that directly related back to what you could program in the service itself, so we worked from that end not from that end.	

KF: Call Waiting came from, we started looking at Virtual Worlds and data navigation, so we started with Emotional Icons, we went from a, we started with Emotional Icons as an idea we visualised it using Virtual Reality (VR) and then we went from that, to data navigation and we moved into the idea that you didn't need loads of icons bouncing around, the biggest problem was finding your way around information, and it was at that point that the particular project that was sponsoring it stopped and there was no funding to take it any further. We were then asked to look at service creation tool which was using the VR that we had done before the data navigation to visualise a service creation tool and that was a really, really complicated system, so rather than eat it all in one go, what we did was we looked at the end result, the service, and we then looked at all the various, I think at that time there were five or six services, star services they were called, because of the star on your phone that would invoke them, and one of them was Call Waiting, and, sat down and modelled Call Waiting. Now the essence of this was very different, we weren't modelling a telephone that had actual buttons on it, we were modelling a service that existed inside the network and therefore we didn't have any precedents to work on, on how to build the model, there also was a problem that all the models of services had been built from the one point to another point was 'a call' and we came up, they couldn't keep drawing lines and lines and lines on a screen we had to come up with a concept for a call that was different than a connection between a and b and that's where we came up with the concept for Call Waiting of an object which was a call, and once we did that we were able to generate the model of Call Waiting as load of blocks and things bouncing up and down, and it got paid for, instead of by the original exploratory money, it got paid for by the service creation tool project. So instead of being corporately sponsored as research it was now part of a development project.		*3b) Within the field and known competitors?* **AC: I suppose that is within BT isn't it. That's the relationship with project as and with bigger aspects within BT, but were you aware at that time of any work going on outside of the company in relation to that whole thing?** KF: Call Waiting? No, in fact on all of the work I have done on Emotional Icons and Data Visualisation, I have purposefully not looked at other peoples' work. Because, my previous colleagues who had worked on Data Visualisation *had* looked at other peoples work and all they were doing was migrating from where the other people had finished. And I believed, and so did our bosses, that we got something novel, and instead of trying to specify the thing to death and then build it, what we were doing was playing with the pieces and then seeing what we had generated whether that could be applicable, so we were doing it the other way around on purpose, it was a different approach.

Current:: 4) What is the relevance of this project in relation to other contemporary work:	*4a) Within BT (human factors)?*	*4b) Within the field and known competitors?*

Q5&6. Units and sub-Units

5) Is this project part of a larger project? **AC: The next point that I have here is in relation to whether it was a smaller part of a larger investigation or a larger part of a smaller investigation, but I think we have already answered that.**	KF: It's a small part of a very large project, it wasn't an investigation. We were looking at ways of improving service creation, reducing service creation time and they were applying what I was doing to that problem. To see whether we could prove whether we could do anything or not, and we did.

6) Is this project broken down into smaller projects?	

Q7. Justification

<table>
<tr>
<td rowspan="3">*7) What was the impetus behind the project:*

AC: The next part I have here is to do with the justification behind starting it and the first part of that is really what the impetus was behind doing the project was and I have a number of different descriptions here if you want to describe it first though?

KF: Why was Call Waiting done? First of all we had come up with loads of ideas and we had never had to apply them to a hard problem. This Call Waiting thing was a hard problem, they had got a visualisation tool for creating services and it was massively complicated and it needed a lot of learning to be able to use it, and they thought that what we were doing would be able to make it simple.

AC: The project that its from, the Emotional Icons project, that is the next stage up. What was the impetus behind doing that? Was it more of an exploration?

KF: That was in the early days of systems research, that was set up to be, to come up with loads and loads of ideas and then float them, right, and then see, because Systems Research was set up with people who had been in Telecoms a long time, it wasn't a load of amateurs in there and we were therefore put into Systems Research to have the ideas that our normal jobs wouldn't let us explore, my normal job wouldn't let me explore it and I came up with the idea that data could have attitude and it could be a visual stuff and I explained that and that's how Emotional Icons got going and it was one of maybe twenty things I worked on as ideas and it was one that Dr. Rudge, who was head of research then seized on and said, spend more time on that. He went through; good, good, bad, bad, bad, good, bad do that sort of thing and it was one of the ones to get on with.

AC: And what were the aims behind that ...some of the descriptions I have here could be things like perhaps technological aspects and investigation of technology, or perhaps that it had something to do with software that was actually developing?

KF: No.</td>
<td>*7a) Advancement of technological know how?*</td>
<td>*7b) Software development?*</td>
</tr>
<tr>
<td>*7c) Dissatisfaction with existing solutions?*

AC: Another thing I have here is dissatisfaction with existing solutions.

KF: It was dissatisfaction with existing solutions *totally* and what we did was we went out to find how technologies could be used to achieve that, so it wasn't a technology driving a solution it was, we didn't like what was happening at the moment and we wanted another way of doing it, we wanted many ways of doing it.</td>
<td>*7d) New product / service development?*

AC: OK, one of the other things I have here is New Produce/Service development. Did that feature in the aims of it?

KF: The only place it was ever going to get used was in a new service or a new product so its ultimate intention would be to be applicable to our business.</td>
</tr>
<tr>
<td>*7e) Other?*

AC: Were there any other background justifications behind it that perhaps haven't been covered here? By these descriptions that I have?

KF: None that I can think of.</td>
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Q8-10. Project Aims and Objectives

Before: 8) What were the original aims and objectives of the project? **AC: In terms of, it was a research project and the goal and aim of the project was to..?** KF: To explore a possibility of 3D data visualisation. **AC: OK, the original aim of the project, was that something that was quite clear right before the start of the project?** KF: No.	*8a) When were these specified?*

During: 9) Did the objectives of the project change considerably over time? **AC: Or was that something which evolved in time?** KF: No, it evolved, we were asked to ...minds roam, we came up with, I came up with ten ideas in about three months with my colleagues, it wasn't on my own and then we had a sifting process and we followed them after that, individual ones that were sifted by a sort of group approval. **AC: Did those aims of the objective of the project, did that change considerably over time?** KF: Yes.	*9a) In what ways?* **AC: Were there any key stages, you could identify?** KF: Once I was able to visualise my idea, so I could have lots of paper lots of sketch sheets, but the moment it started bouncing on the screen it was then immediately accessible by everybody, not just within my group, but anybody could watch it and anybody could watch it and understand it and in fact that was its greatest strength because it obviously worked because I didn't explain it to anybody. It immediately became self-selling. It then became a demo that was always shown and what was interesting, because it was so bland and so basic, we could apply it to any customer we were talking to. It was *core*, not an example of home shopping or anything it was just core data so you could apply it to anything. **AC: So it was a mental model it kind of worked with many different?** KF: That was Emotional Icons, Call Waiting came some time later, let's get them right, and Call Waiting was never really shown to the people who could have adopted it. It was shown to the people who sponsored the service creation tool and in fact, what we developed was a way of visualising services to the end customer not to the person who was building it. **AC: So was there a particular reason why it wasn't shown to the people who might be developing that kind of tool?** KF: Politics, it was too much for that end customer to swallow at that time I reckon, too big a leap of faith.

KF: The comment that was made was that Emotional Icons and Data Navigation was research, now do something real. And the real thing we did was Call Waiting and it was a lot more difficult to apply the ideas we had to a real service and we came up with the initial Call Waiting demo and that had lots of backward implications back into research and so we took it forward and then it prompted a lot more research.

AC: So the Call Waiting side of things, the context within which the application of the Emotional Icons research, is that just fortune that that particular project came along at that time?

KF: Yes, purely fortuitous. Basically they were the only people who had some money who actually had something that we could apply it to and it all happened at the end of a financial year when they needed deliverables and we needed money.

AC: But actually it proved to be quite a useful project?

KF: It got used out of proportion to the amount of time and effort spent on it. Yes.

After: *10) Were all the project objectives met?*	*10b) If not which were not met?*	*why?*

Q11-13. Project timing

11) When did the project start?

AC: If I could just go back a bit further behind, from memory can you remember when the project first started?

KF: Four or five years ago.

AC: The Call Waiting part of that?

KF: Three to five years ago and it was all done at that time, bang, in quite a short period of time.

12) What stage is the project at within its original time plan?

AC: And that project...where is that within its timescales?

KF: Now...its had its useful life. It's as an idea sitting there as a latent idea that we can apply anywhere, and it doesn't have an owner other than me, its dragged out every two or three months to be shown to somebody and nobody has as yet copied it.

AC: Within BT or?

KF: Outside BT, it's been shown outside a lot.

AC: Is there a reason why that may be do you think, or?

KF: No, I think it did what it was supposed to do, which was to prompt the idea that you can think of different ways of creating tools different ways of visualising things, and with the advent of the net and the advent of screen phones, I think that this will become a way, it will migrate to a way of showing services to customers, explaining things, but its day hasn't come yet.

13) When did/will the project finish? **AC: So do you think that the, has the project itself finished?** KF: yes it finished when the money ran out.	*13a) did/does this represent a natural conclusion for the work?* **AC: But you don't see that really, or is that a natural conclusion, or is that?** KF: The ideas there, no, no. That was successfully did what the money was there to pay for it. Better than they expected. But the ideas still exists and a lot of the people I work with know it, so it's in the back of your mind when you are developing other things.	*13b) why?* **AC: So it's more of a ...partly, a stepping stone to a ...** KF: Yes a stepping stone, definitely, a long time ago.

Q14-15. People

14) Who are the key people involved in the project: **AC: In terms of the people who were involved in it?** KF: There were really only three; myself, Amanda Oldroid, who did the next version which she did when she joined the company, the first job she did was to take my demo and make it much more customer facing. And then the third person was a guy called Brian Salt, who was the guy at Superscape, the software company, who helped me build it, because I didn't know how to drive the tool then. **AC: And the three of you were the only people really involved in it?** KF: Yes, I think, there's only two of us on the patent Brian and I. **AC: And, the Superscape chap Brian, He's not BT at all in any sense so he is totally external to it.** KF: And he built, I had the idea, I built a very crude model that didn't work and I went down to do a training course to learn how to build with the tool and as a training exercise he and I together built my model, and that's the same model that you see today, it hasn't changed. **AC: And is that the only involvement that he had, is in that training?** KF: Other than his enthusiasm and his instant understanding of what I was trying to do. If you haven't got somebody who understood the idea that we were trying to make models of things that didn't exist, rather than Virtual Reality, this is Virtual Unreality, if you know what I mean, because a call doesn't exist as an object. **AC: People have modelled it as, as you say between two lines as an idea but it's difficult to do.** KF: We couldn't do that, you run out. Ten lines off, ten lines and you've covered the screen you know, and nobody would gain any benefit from that.	*14a) Management?* *14c) Design?* *14e) Marketing?* *14g) Evaluation?*	*14b) Strategic planning?* *14d) Implementation?* *14f) Delivery?*

15) What are their backgrounds / what is their expertise? *(animation, graphic design, software development, industrial design, three dimensional design, computing, psychology, human factors...)* **AC: Here I have got a list of areas involved in it would you say that it had covered these areas or?** KF: The only people who really got involved in it were people who were researching user interfaces in our own area, people who were researching user interfaces in the service creation area which is different. And since then lots of people in the development of telephones and the services have seen it, but more passively, nobody was actively involved in it, because it was a very simple start. **AC: And, Amanda's background is?** KF: An animator, she came in here and it nearly killed her, because she had used an animator friendly package before and she came to change my demo to a different one, to a more professional one, and she not only had to join a new company but she had to learn an unfriendly package and then do something creative with it. **AC: And that package is?** KF: Superscape, as was, it was version 3 then or 2.5, I think maybe, it's now 5.5 some four of five years later or so, it's very difficult to know, your paper work will tell you when it started won't it.	*15b) Do they all work for BT?*	*If not, who do they work for?*

Q16. Data Sources *16) In relation to this project, what information is: (where is this stored)*	*16a) on file (folders, project reviews)*	*16b) on the internet (html pages about the work)*
AC: Yes, there are questions that we will come on to that relate to the software specifically. The only other thing I have in the background here, is in relation to places and sources at which the information was disseminated. The example I have here. I have a copy of the file and folders, which I know of in this case, was anything ever put on the Internet about it? KF: No, the Internet didn't exist then really quite in the sense that it does now. It did, but it wasn't somewhere you would publish. **AC: And nothing has been published there after?**	KF: Yes, yes, an article about Emotional Icons that included Call Waiting was published in a joint article written by myself and Martin Cooper and that was for a BTEJ article... **AC: BTEJ?** KF: Engineering Journal (BTEJ) or Technical Journal (BTTJ) article that's published externally. It's a sort of thing like the publications from Bell Labs, you know, its one of those type of publications. So it has been published. But it had to be patented before that. KF: What we were doing using, What came out of it, out of Call Waiting, was the concept of a virtual reality object with code attached to it with attributes so you could use it like Lego bricks and build services, and as you built them in the virtual world they worked, but then you threw away the visualisation and you had written the code. So it was Virtual Reality object orientated programming came out of it. And that was what was patented.	**AC: The other things that I have here on my list here there has nothing put on the internet since then about it?** KF: No, Well you can find it, but it is referenced from Peter Cochrane's site. The emotional icons will refer to Call Waiting and Peter Cochrane refers to emotional icons and he has used it I think in his book. **AC: So he has referred to it, but there isn't a specific site about it?** KF: No, no. It's a part of a part of a part of a project. *16d) on computer (interfaces, demos)* **AC: And we have got the computer demos, is there two demos?** KF: Yes, there was one that Brian Salt and myself produced and then that was just Call Waiting. And what we then fed that back into the services project you know that it was delivered into. And we got some money the next year for Amanda to look at all six services using the model, grow the model, to include the other services, so it went from Call Waiting and then it was looking at call timer, and call divert using an expansion of the same model and three way calling. There were five or six star services. Built on the same pieces and built the other services, or tried to. And then it was at that time that that I think that project was stopped as well, but not because of us, but because of other things. **AC: Why was it stopped?** KF: I think that basically the funding was cut because it was an enormous project. And we also had other things to do, so we just left it part way and they just used the demo. **AC: It wasn't because it was an unviable idea.** KF: No, no. The other thing that was suggested that we go out and market it inside the business. And at that time we had been asked to do something far more marketable, so we got on with that rather than continue with the Call Waiting and the service creation side.

	16c) on video **AC: Is there any video data around on this?** KF: I've got some video recordings of it on screen, here.	**AC: And the other of the five star services, were demos made of those?** KF: No, the pieces were built but we had never made the final model, I can show you those. They would have just been building rather than being innovative and creative. We had got the pieces it was just like using the Lego to do something different. We had built the original pieces to be able to make all five of them or six star services. We had a problem with three way calling - It was extremely difficult idea to model. Because there is one characteristic of three way calling is that who ever initiates the three way calling sort of owns it, so if they cleared down it clears down everybody else. **AC: Was that difficult to represent?** KF: It was in the logic that we had already used up to that point because it didn't have any modelling of, who on the call, who was paying. KF: Nobody owned the objects in the model that we had up to that point and it wasn't until, owned the call, because in a normal call either end can shut down but one is paying for it. But In a three way call the other two people can go in and out, but if the originator went out the other two would fall out. **AC: It was more of a hierarchy?** KF: It could be but the whole thing about a three way call is that when it is happening there is no a hierarchy. And we were talking about call hierarchy not charging hierarchy, we were always talking about connectivity not charging in all the models that we had done up to that point it had got no Lego piece for charging in it. **AC: Was there ever a desire for having to have that?** KF: The reason for doing Call Waiting was that people didn't use it. And the reason was they didn't have an understanding of what it could deliver and b how to use it. The human factors approach was that they didn't have a mental model of what it was. So we built a virtual reality mental model and that was the use for it and once they had a mental model then they found it much easier to operate it.

	16e) physical imagery (story-boards, renderings) **AC: Is there any story-boards or renderings any physical drawings.** KF: No, no it was never drawn. It was always built in the model. Amanda may have done some drawings but to be honest I think she modelled them. **AC: There were no three dimensional models of it done?** KF: It was a lot easier to do it on the screen than to do it as an object, because it wasn't an object. **AC: Any newspaper clippings?** KF: No, none on Call Waiting alone it was part of the whole idea of emotional icons data visualisation. It was never on its own.	So it was to do with people and use not people and charging. **AC: And there was no way of adding on that?** KF: Yes we could. But, we could crack all five but not the six without the charging thing. And the charging, to be honest, didn't add any value to the user interface we spent a lot of time trying to work it out and I'm sure we could do it now but it seemed insuperable then. *16f) external review (published at HCI, newspaper clippings, television broadcast, interviews, technology exhibitions)* **AC: In terms of external review was anything published any HCI events?** KF: Its been shown, It has not been flogged to the HCI community at all it has been flogged straight to the end customer so it appears at BT high technology exhibitions to real paying customers, you have got to bear in mind that initially the work on it wasn't done on the human factors division it was done in systems research and then I migrated into human factors and that's when Amanda came in. And we weren't integrated into human factors as such because we were in a different room for another year after that. So it was probably done on the edge of human factors. **AC: Was it ever televised?** KF: Yes it has been on television Channel Four; well it's only used as a sort of two or three second bouncing icon. Things like 'London in the next millennium' was one programme, because they were looking at what would happen to the city when technology hit it. And this is the type of technology that would help city traders. I've got a copy, its one of the demos that gets shown and bits of it are just sort of used as filler. **AC: Did you do any interviews on it?** KF: Not on it specifically. I did present it to two or three particular groups of people for the service creation project. So there were two or three major project reviews, and I presented it along with all the other software and ideas so I was one of eight or ten exhibits.

Main Analysis technique Breakdown - The Design Solution (Interface)
Q17&18. General

17) What is the purpose of the interface?

AC: This is the second part of the semi-structured interview. The questions in this section relate to the actual specific interface part of the project rather than the context within which that is. So if we take the actual Call Waiting interface itself, what is the actual purpose of the interface, I suppose in its broadest sense in a general way?

KF: We were actually, the demonstrator we created as a model for service creation software writers to help them build services using pieces of the network as objects and sticking them together, network functionality, and sticking them together, and we found that there were three particular customers actually for a model. One was the people developing the service another one was for people who selling the services and another one for the customer who was using the service. And prior to this there has been one model of how it worked for the programmer another one of how you would sell it and the third one was the customer experience which was horrible.

KF: For the first time we had generated one model that could be used by all three, and therefore what the customer, the end user, didn't like could be directly translated directly to the model that the programmer was using and this was the essence behind its success. Was that all three the customer, the person selling it, and the person designing the service could use the same mental model in this case it was visualised as one model. That was the reason for the interface or what it was and therefore any of those three people could use it and get something out of it.

AC: They are very different audiences?

KF: They are human beings so they are all the same. They just have different levels of knowledge of the service that's the answer I always gave, a bit bland.

AC: was it created with one particular group in mind?

KF: It was driven by the one in the middle people trying to sell or explain the service. Either to say is this what you have designed you Mr. systems designer or this is how you use it to the end user. It was actually designed for use by the people trying to explain or sell the service. Rather than the end customer or the software engineer that's who it was aimed at.

AC: And in that sense did it also meet with the people on either side of that?

KF: Yes, in fact it had very wide appeal, it even had an appeal to software designers but didn't work on service creation because they could see if they had a tool like that for their particular software problem they could use that approach, which I believe we could call the emotional icons approach.

AC: So the fact that it was a visual interface that suited all three

KF: It was the only type I knew how to do. If I knew how to do an audio interface it would probably be an audio interface.

AC: So the interfaces that the groups used to have, what were they?

KF: The services creation designer had a very, very complicated very technical version of boxes and lines it had intelligent boxes that knew you could connect that box to that one on a UNIX system. The person selling had nothing other than that they went on training courses of how to use the service and were given a load of bullet points.

KF: And the end user had a manual that the human factors spent a long time refining. But, it was like trying to make a silk purse out of a sow's ear. Because all the button codes were being set by switch manufacturers from software engineers they weren't being put together by human beings they were things left over, legacy systems that were now being forced through codes to do jobs for customers.

KF: So they had a very difficult job explaining this logically from the codes, you know, Star hash fifty three hash is not a logical way of interfacing with Call Waiting.

AC: Do you think that that mode of describing it suited any group more than others.

KF: Which the visual mode, the three D? The engineers, no, it was just legacy for them. They really didn't care it was just what was left.

AC: Is there a copy of the guidelines that were created

KF: Yes you could get those it comes with any star services manual it's probably in one of the books that you have. KF: Because the very first work we did was we cut out little counters which were the keys, and we laid them out and tried to animate them to begin with. And it didn't work. And that's when we realised we were trying to animate a line between two numbers. And it just wasn't working.

18) *Was there a brief?*	18a) *If so what was it?*
AC: Still in general terms, was there ever a formal brief for it? KF: Yes, there is a little document it came from a Don somebody or other, who is still here, and he is seriously clued up on service creation tools. That book he knew inside out, all the things you had to do to create a service, he knew it, in here, and so there was no point us reading it because this guy actually understood it. He wrote a very short A4 of what he wanted to get out the end he wasn't telling us how to do it. He wanted a demonstration that reflected Emotional Icons as applied to a service creation, that's all he wanted at the end of it. KF: Ultimately, he wanted, when during the project, what it looked like we could create would be a set of pieces in VR that reflected the pieces of software functionality inside the telephone exchange and what we were going to get if we carried on working with it, was a set of pieces that any customer, like a telecoms manager in Waitrose, could on his PC, stick the pieces together and say that's what I want and send it back as a requirements document, back to BT that's what they wanted because if you sit down you only get an hour to talk to the telecoms manager but if we gave him a toolkit in VR he could stick all his services together and route them all together and build a model and test it, he would spend hours doing that, he would then save it on a disk and give it back to us and we would get a very, very much clearer requirement of what the service was, and that was the ultimate aim after we had started the project, we never got to that stage because I think it got axed, not so much axed as a technological or a BT shift, like we're not going to develop services we're going to do something else, and whoosh the whole team went over to do something else.	

Q19-23. Building the Virtual World

Software: *19) What software tools were used to create the virtual world?*	*19a) What is the release no. for this software?*	*19b) Does this express the state of the art use of this software?*
AC: If we have a look at the software and hardware side of it. We've mentioned already that the software to create Superscape. Was there a release number for that?	KF: An old version that ran inside DOS. I think it was 2.52 or 2.53.	**AC: Did this represent the state of the art for use of this software?** KF: Yes. **AC: Did this at that time or does it now?** KF: At that time it was the state of the art it is still state of the art but its on version 5.5, it runs inside Windows 95, it doesn't run any faster than it used to. Its just the processor speed has gone up and they have added all this rubbish to it.

	19c) Has this software changed considerably over time? **AC: Between the early version that you had there, has that software changed considerably over time?** KF: O' fantastically, before you had to be a coder now a designer can use it, and that's why I worked with Brian Salt there was nobody in the business other than Paul Rea who knew how to drive it and Paul was using it to do something else so he hadn't got time to teach me. **AC: Are there any specific aspects of the software that make it easier to use as a designer now?** KF: It's basically following all of the Windows conventions now instead of being a stand alone DOS application that you had to learn. KF: The biggest problem was it didn't seem to have a logical tree structure to the commands when I was originally using it now it has tree structured all the commands logically whereas before there was a logic but that was the logic of the designer not any other. The logic of the person who wrote the software. **AC: So it has become more universal?** KF: Vastly more so. A lot of the things you used to have to code have now become buttons to apply it to so whereas before you used to have to give something velocity or gravity now every object is created with gravity and now you just change it. Do you see what I mean? Everything had a palette of colours instead of defining a colour. All those sort of things have changed.	*91d) Is it expected to change considerably in the near future?* **AC: Do you expect the software to change considerably in the future?** KF: O' yes. **AC: Are there any specific areas that you think might change?** KF: I think it will become universal in the sense that there are two standards at the moment or two that I use, one is VRML the other is the VRT format which is Superscape. VRT and with the advent of web browser plug-ins Superscape have developed the universal player and they have made their software save in both and load from both formats. So they have got rid of the standards problem.

20) What was the justification of using this software for the project?	
21) Did the software represent an ideal choice? **AC: So was Superscape the ideal choice for that project?** KF: There were two other, it was for me because it was the only type of the three types, there was another one that Gary Dalton used at the same time, I wasn't working with him at that time, that was called photo VR which was an early precursor of a cross between QuickTime VR and Superscape. **AC: You mention photo VR, was VRML around at that time?** KF: Possibly, but only in a University, probably free, not really an alternative, not that I know of, there were an awful lot of modellers there were hundreds and hundreds of modellers and animators but there weren't any dedicated virtual reality, o yes there was there were there was Virtuality but theirs was a custom built suite of software which they used on their own headsets and they, they never released to us a toolkit that would allow you to build the worlds. They only sold us the kits we bought number one and number two. I didn't, they were bought here before I was involved in VR, Laurence Bicker bought them.	
22) Do you think that the software constrained creativity or facilitated the development of concepts? Please give an example. **AC: Do you think the design of the solution would have been very different with different software?** KF: No, but the visual of rendering, maybe the ease of use, yes, but the thing about it is that VR software is a bit like a camera, if you cant take a picture it doesn't matter what the camera is. So we were going to get these ideas out. It was the ideas not the tool that was the problem.	

23) Would it have been possible to create the virtual world using different software? **AC: Would it have been possible to create the virtual world using different software at that time?** KF: Yes, there was something called world toolkit and we had a copy of it, that was much cheaper. To colour it and another piece of software to stick the images on and another one to stick the sound in, right, they were all separate pieces of software themselves and they didn't all talk to each other and Superscape was the first one that put them all together in one piece of kit, in a compatible, and they stored all the pieces together whereas before you would have your wav files here and your image files here and your model files there. Superscape stores it all in a VRT file.	*23a) What software?*	*23b) If so, would this have changed the design?*

Q24-33. Delivering the Virtual World (hardware and software)

Software: 24) If different, what software will be used to deliver the product/service? **AC: Was the software that would deliver the service / product interface different from that which made it?** KF: Yes, it would have been, what we were ultimately going to do with it was, we were going to stick it on a CD that you didn't see Superscape on it at all and it would have BT written through it and it would be used by a comms. manager and there was another so it would have been totally unbranded, it may have used their renderer or it may not, it would have been stand alone package. There was another use for it, on black and white screen phones, LCD screen phones, we were going to replace all the star dot star with a little screen a dot matrix screen that had the service modelled and animate it from our drawings or our pictures back onto the screen phones. So you could touch a call and drag it, and we did storyboards for that but then lots of screen phones were coming in at that time and they were going to be big text and buttons all around them. ADSI phone, but its interesting to see that that did not take off and what's happened is that the BT magic phone which is a Windows phone and that's coming out.	*24a) What is the release number for this software ?* *24c) Has this software changed considerably over time?*	*24b) Does this express the state of the art use of this software?* *24d) Is it expected to change considerably in the near future?*

25) When was the means of delivery identified at the start ,during, end?

26) What was the justification of using this software to deliver the project?

27) In terms of delivery did this software represent an ideal choice?

AC: The actual software that delivered the service, was that chosen up front or was that just something which just?

KF: It would be the final delivery platform, it was independent we hadn't got aspirations to do that work, we had got aspirations to move to the next level of funding, we hadn't got aspirations, we had got aspirations but no plans to move it to a different platform. There was no problem in platform. Because what we were sorting out was the idea, not the execution, we hadn't got the idea right. We were using it as an ideas visualisation.

28) Do you think that the software constrained creativity or facilitated the development of concepts? Please give an example

AC: In terms of the actual delivery software, did it affect the design as well?

KF: Yes.

AC: In what ways?

KF: limited palettes, limited ability of the person building the model, you know, there wasn't a piece of software then that was easy to use, this was the easiest to use. And things like - there was a model of a telephone its not a BT telephone but as it was easier to use one that already existed, we used it, it was in fact a Bell telephone model, our competitors, from Bell Labs, it was one of theirs not one of ours.

29) Would it have been possible to deliver the virtual world using different software?	*29a) What software?*	*29b) If so, would this have changed the design?*

Hardware

30) What hardware will be used to deliver the product/service?

AC: If we move on to the hardware side of things what hardware requirements were there to deliver the service?
KF: To deliver what Call Waiting? As my demo? or the actual final service Call Waiting needs a complete national telephone exchange system to deliver the service Call Waiting but to deliver my demo you only need a PC, I think we were running it on a 16 mega hertz, DOS 386 or something.
AC: I think the question will need to relate to the actual service to the customer but in this sense we can use in terms of the demo.
KF: It would be run on a very basic PC it didn't need anything special, it would need a sound card which was difficult to find throughout the business so I used to probably lug the PC around because mine had a sound card they weren't common.

31) What is the optimum/minimum hardware standards for running the virtual world?

AC: What would be the optimum system hardware to run it?
KF: Anything, a Pentium, we were running it on 386s and 486s, and it just gets, the animation is such that if you move from a-b on a fast machine it does more cells in-between but the time from a-b is the same, whereas if you've got a slow machine, the time from a-b is the same but you just get one cell or no cells, it just goes bang bang. And so adding speed to it or memory just makes the animation smoother it doesn't add to the actual function.

32) How did this affect the design?

AC: Did the choice of both software and hardware affect the design of it?
KF: Yes, it would have.
AC: In what way, did it constrain it or did it...
KF: We made the modelling very, very, very, basic so that the machine could do it in quicker frames.
AC: In what sense do you mean basic?
KF: Instead of showing the call as a sphere with lots of facets on it we would make the call a cube with six facets on it, instead of 160 or something, it didn't look so posh, it didn't look like a ball bouncing up and down it was a cube.
AC: The less facets the faster it would run?
KF: Yes, yes, yes, much faster.
AC: Were you limited in the amount of memory / facets you could do at that time?
Yes, yes, we were down to less than a thousand facets if we wanted to render anything over about five or six frames a second.

33) Do you think that the platform for delivering the virtual world constrained creativity or facilitated the development of concepts? Please give an example.

AC: Do you think that the platform for delivering the VR constrained creativity or facilitated the development of concepts or perhaps both?
KF: I think the second one, it facilitated. Given an infinite piece of paper you don't know where to start you've got a load of constrains in there you can be highly creative in getting the most out of it.
AC: So did the software play a part in the design?
KF: O' yes, in the sense that it had functionality which we used to get our ideas across. Let me see if I can explain that. We can flash an arrow ever so easily whereas to get an arrow to move wasn't easy. So we flashed the arrow. Right.

Main Analysis technique Breakdown - Interface Descriptive Content

<u>Interface Descriptive Content</u>

Q24-33. Interface Identification Overview

34) How many different discrete visualisations have been created for this project?

AC: The first one that I have here is to do with just the interface itself as an identification, as an overview. How many discrete visualisations were actually created?

KF: Two.

<table>
<tr>
<td rowspan="2">35) Which design represents the most advanced solution in terms of:

AC: Which would you say represents the most advanced of those?

KF: The second not this one the one Amanda did.</td>
<td>35a) Usability?

AC: I have some terms here perhaps the most advanced in terms of

AC: Usability would be?

KF: Amanda.</td>
<td>35b) Challenging conventions?

AC: Challenging conventions?

KF: Mine.</td>
</tr>
<tr>
<td>35c) Commercial viability?

AC: Commercial viability?

KF: Amanda's.</td>
<td>35d) Other criteria?

AC: Do you think that there are any other criteria which could isolate the two?

KF: As we made, what we found with it was, as we refined the model and the user interface to telephony it was less easy to apply it to other services or even use it as an example of how Emotional Icons could be applied to different jobs or whatever. As it gained a context it lost its ability for people to understand it.</td>
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Specific Interface Identification

36) Does this interface have a title or name to characterise it?

AC: Does this particular interface have a name that you can characterise it with or is it just yours and Amanda's?

KF: This one is mine Amanda's is a very different way of doing it. In fact she modelled the objects differently and what she did was, she, this one was totally dedicated to Call Waiting. Amanda's is a demonstration that is made out of Lego pieces that works similarly but also have the ability to be used as Lego pieces for the other services. This one didn't.

KF: There was one other concept in this which I always used to demonstrate it was I put it into toolkit mode and say that one of the things the customer could do was instead of two call stores they wanted three, you could pick a call store and then say that was an object, duplicate it stick on another one and you have now created a service right, with three call stores. You could then run the service, yes, now you have created one with three call stores and you could see that you have made programming errors, you see what I mean, so not only could you use the tool to visualise the service you could build services with it run them and see where the bugs were and if you actually go back to the original thing you will find that if you go up one, that is the group which is the Call Waiting and this object was never part of the whole of Call Waiting so it was never adopted, if that had been adopted, bonded to it as an idea, it would have worked with it. And it sort of shows how the structure. And also when you copied these objects along with it that's the code and that could contain the code from, that's needed to drive the telephone exchange.

AC: When the engineers were driving it before were they just doing it in command lines of text?

KF: No, they were doing 2 D objects and then they would, that wouldn't create copies of code though that would only give structure and It wasn't animated it was just purely a flow chart. It did have rules on you couldn't connect this to this, it wouldn't draw a line if you tried to because there wasn't a communication channel or something. Whereas this is completely different. And yet they understood it.

37) Describe the key features of the interface?

KF: Basically, we provided two areas on the screen the 3D world here which we used very little of the ability of the 3d ability of that the ability to fly around we don't use that a lot here. And the other side we put in function keys down the side and what we did here was we had the idea of a telephone exchange functionality as the blue bit in the middle. And the calls came in and they could go out. Right, and we had a telephone to which the exchange could send the call. And then we put a big button in it that allowed us to turn calls on and off inside the world.

There is a keyboard on the telephone here and, but, what we found was that was too difficult to get at sometimes so we replicated the keyboard up here, and we also started putting in functions here that would show you what was going on in the system because there were lots of indicators that the service was creating all time you do a call like it would know; who it was from, who it was to, call duration, who was paying what the cost, all sorts of things. But we only left it as the length of time of the last call. We, one of the interesting things was as this was the very first model we didn't know where to put the code so we actually made some chips that live in the world to put the code into, because we were starting to design something that didn't exist.

Where as before you would put the code inside the object yes? First of all it had sound so you could send in a call and then we used convention here to lift the handset, there's a rendering error there. And we added a bit of emotion to the call itself so it started talking to you and you can see a flashing arrow to show that you have received a call and it is sitting in the tray.

KF: In Call Waiting you can store one in the exchange and listen to another and then you can switch between them. So in comes a call and you answer it and then what happens in Call Waiting is while you are on the phone another call comes in and what happens at the moment is on in your ear you get a bleep. We put a sound in relation to what it was trying to do in the model and then we go over to the logic that is associated in the telephone exchanges.

KF: And we made it just pulsate and it shrinks and it was going to turn bright red and get angry after a long time, but we never got it to that point. And then you press two and it moves the call that's come in to the other tray, yes, and that's what happens in the exchange so it puts one to one side and then it puts it in. And you are now listening to that call. To go back to the call before you have to put the one you had on hold which is 'r' and '2' again and it switches back and the call reactivates and it leaves that call and you have got two call stores, basically. That's what you do 'r2r2r2' and in fact some of the customers call it 'r2d2' rather than Call Waiting because that's what you've got to do. And 'r' will in any service put the call on hold before you do something else, so that's a consistent function.

AC: Does 'r' stand for anything?

KF: Recall, it means sending a recall tone down to the line to the telephone.

KF: Then when you put the handset down the call clears away and the call that's on hold phones you, the exchange calls you back. So what you do as a customer, lift the handset and were stored. Well it was just held not stored and then you clear down and you killed the call and it resets again. And that was the whole of the Call Waiting idea there.

KF: Do you want to see Amanda's version?

AC: Yes

KF: So we have not really used the 3d ability world really, we used it as an animator really. These are all demos strung together.

AC: If we stick with the one at the moment we will go to Amanda's at the end.

KF: Ok, so you want to go back to Call Waiting.

KF: That's Call Waiting they are all tied together.

38) Is the existing visualisation an example of on-going design or a finished concept?

AC: Is this particular visualisation an on-going design or a finished concept?

KF: Finished.

Use of different media / modes of representation

39) Describe the different types of representation used in the interface, are there: **AC: In the interface you have used different types of representation for example 2D, 3D image, numerical and textual data?** KF: Which one is on top of which? **AC: Would you say that all of those were used in this particular one?** KF: Yes, they were all mixed together, not very well. But once the idea that there was a 2D activation window and a 3D visualisation - That everybody understood. It was when you started to being able to activate in both the 2D and 3D, they started wondering.	*39a) Two dimensional images?*	*39b) Textual information?* **AC: Was it clear when it was right to use text when it was right to use images when it was right to use words?** KF: It didn't really come into it. We weren't after using text at all. The use of sound was a shock really because it was so powerful. So text didn't really add anything other than, I mean you could take the 'c' off that button and it wouldn't mean anything. **AC: Things like the last call time was it critical that that was in text?** KF: Yes, there wasn't a symbol that we could we did later. **AC: And the number key pad the numbers had to be there because that was the way...** KF: That's the only way that the customer has to interface with it, the person who uses the service uses it through a keypad. **AC: So presumably if you went for the screen based one you wouldn't need that keypad?** KF: No, just touch it and drag it, and it would send the codes, you could probably hear it but you weren't typing in the numbers any more.

	39c) Numerical information?	*39d) The impression of three dimensionality? how would you characterise the three dimensional?* **AC: The three dimensional aspects, how would you characterise those in relation to the others how could you characterise the three dimensional?** KF: An extremely powerful way of visualising your ideas, they are interactive, they are so much easier to create than an animation. And they are much more flexible. Like you want an animation to lift the handset and you have a problem and you can't get out of the problem. Whereas with this you can change viewpoints and everything. The file is tiny its probably 300k and you can give it to people. Whereas a big animation to do all of this would be enormous.

40) Does the 3d exist within a 2d metaphor or the 2d exist within a 3d metaphor, which would you say is the main mode of representation?

AC: Does in this instance the three dimensional aspects exist within a 2D world, or do the 2D aspects exist within a 3D world?

KF: You've got both, 2D inside a 3D, 2D on top of a 3D and the 3D is within the window of a 2D machine. Doesn't confuse though, I don't think.

AC: Were there specific ways of avoiding the confusion between those.

KF: It never ever contemplated as being a problem, it's a bit like the guy who invented the mouse - He said he didn't know it was difficult. It was never even contemplated, we did what was necessary to create, we weren't trying to stop using or start using anything we just used the bits that worked.

Functional content / command /control

41) Can users change information which is displayed to them, what level of change can they exert? high - low / none

AC: Can users change the information that is displayed to them and sort of what level of change can they exert?
KF: Very, very, little at all, the user.
AC: In terms of the amount of control that the user can exert...
KF: Very little at all on this demonstration, none. I would say the only thing they could do is change the viewpoint. But you've got to get the user and *user* right. The user of it is demonstrating to somebody else.

AC: The person who is interacting with it

KF: Can move the viewpoint.

AC: And would they want to do that?

KF: It doesn't add anything to the explanation at all, it's basically a fixed animation in front of you. So what was happening was that these objects were moving like that, forget it I will just reset the world.

AC: Can the person who is interacting with the interface change the interface? You demonstrated before how to add a new piece of code.

KF: Only if they had the toolkit. it wasn't built into the demonstration.

AC: But it was intended that the end user the customer would be able to change?

KF: Yes yes it was intended but we never had the runtime demo of building things like that I hadn't learnt how to do it. It would happen yes.

42) How interactive can the interface be considered? high - low / none

AC: How interactive would you say the interface is?

KF: It is extremely interactive in the sense that you perform a function like invoke a call and in comes a call and it does things and when you click on the handset it does handset things. Yes, it's quite interactive like that.

AC: How would you characterise that?

KF: It has a logical visualisation. Which, rather than, you don't have to drag everything around you press a button or you put a phone down and other things start to happening so its interactive like that you don't have to push the call down you don't have to do this or that.

Navigational / Interactive content

43) Is the interface immersive, screen based or both? **AC: Is the interface immersive screen based or?** KF: It's screen-based its Fish tank VR.	*43a) Why was this chosen?* **AC: Why was that chosen?** KF: We didn't have the ability to programme the immersive equipment and I have a personal dislike of immersive systems if you are trying to teach somebody or show somebody it's very difficult. **AC: So that's one to one, computer to person.** KF: Or one to twenty we used to have crowds of people round there, a few years ago it was novel, it doesn't look it now. But it did then, its certainly not immersive it's hardly VR it's just three dimensional animation.	*43b) Has it always been like this?*

<table>
<tr>
<td rowspan="2">44) How can a user can navigate the space: i.e.

AC: If you could describe ways that the user can navigate the space?

KF: There is no navigation.</td>
<td>44a) Free movement, 2axis, 3axis?

AC: There is no navigation at all, some of the things that I have here, are: is there is free movement?

KF: There is in three axis it adds nothing, its there.</td>
<td>44b) Multiple vantage points?

AC: Multiple vantage points

KF: Yes, whoopee.
KF: Not used in this one.</td>
</tr>
<tr>
<td colspan="2">44c) Fixed paths?

AC: Fixed paths?

KF: It's possible to put them in but they weren't used.</td>
</tr>
</table>

45) Describe the 'action concept' metaphors within the interface: i.e. **AC: In terms of this has been described by some as action concepts, metaphors in which you can interact? So they have described move which includes, navigate, fly, drive...** KF: You can do all that but it is not used in the demo. The software is capable this thing can fly around, I can add click on and fly to, to it, it's not used to demonstrate it. The one thing that is used in here is distancing which is a VR concept you see the keys that's to speed the rendering.	*45a) Move: (purposeful traversal) navigate, fly, drive, click and fly to?* **AC: Would you use the Superscape control to fly around?** KF: No activation on that. They are purely viewpoint modifications that's all they do they move your viewpoint around. The other standard mouse is used to activate or drag things.	*45b) Browse: (low goal orientated review of options): Rapid replacement, scanning text*
	45c) Lines, window shopping, thumbing through books?	*45d) Scan: (very rapid browsing) fast review of scrollable items, fast review of buildings, objects, people?*
	45e) Locate: point, touch, circle items?	*45f) Create: add (new), copy?*
	45g) Delete: throw away, destroy, lose, recycle, shred (permanent or temporary deletion)? **AC: Is there any means of delete or throwing things away?** KF: No, there is a reset the world which is the most important thing in VR ever invented. Reset the world, bang, and then you carry on.	*45h) Evaluate: point, touch, circle items?* **AC: Interaction descriptions include Pointing or touching or circling items and so you have a cursor there you use that?** KF: You would use it to pick it. To pick up the handle and things like that.

46) What forms of input device can the user employ: **AC: In terms of the envisaged customer user interface?** KF: There would be no flying they would be able to rotate a viewpoint, they might have had click on and fly to, but it was mainly as a cheap animator. Instead of storing animations you stored a world and then you moved around the world which was much more software and memory cheaper than storing massive sets of animations.	*46a) Keyboard (typing/numerical input)?* **AC: The input devices that you have, did it use the keyboard at all?** KF: Yes. **AC: In what ways was the keyboard used?** KF: O' no on this demo, no, it is not used at all other than reset the world.	*46b) Space mouse?* **AC: Is the space mouse used?** KF: Yes, or you use, well the control bars on the bottom here never existed when it was developed, or you could use the keyboard fly buttons by holding shift down and you also have this function which is a space bar and an ordinary mouse flying. **AC: And so at that time it was using?** KF: I used the space mouse most of the time and we could use these buttons as well they are disabled now, but when it was a dos application you could use those as well.
	46c) Normal mouse (in conjunction with browser navigation window)?	*46d) Any other?*

47) How has this affected the design?

Navigational Architecture

<table>
<tr>
<td rowspan="2">48) How might the mode of interacting with the information be considered:

AC: In terms of navigation would you say that the interface is hierarchical in terms of the way the information is put forward?

KF: No, I would say that it is practically random. It was generated and then found easy to use by people who knew how to use it, there's nothing in there that would tell you how to use that.
So there is no hierarchy there at all, you've got to know what it is but once you know it, it is terribly simple. There's only about three things that you can do.

AC: So there's no kind of obvious path through it?

KF: No, a person demonstrating it has a definite path but no obvious path there's no set of buttons along the bottom. It was only going to be a visualisation of a way forward and what happened to it was that It got left there it was never going to be the end result, it was a means to an end and it stayed as a means.</td>
<td>48a) Hierarchical?

AC: In the terms of information that might flow as a hierarchy

KF: There is no information flow there at all.</td>
<td>48b) Networked?

AC: Networked information might flow?

KF: Never, It was never networked never, never you have got to think of it in the days of dos on a stand alone machine.</td>
</tr>
<tr>
<td>48c) Linear (fixed path)?</td>
<td>48d) Hypertext / hyperlinks?

AC: In this interface were hyperlinks used?

KF: No, I put them in afterwards to help me when I'm demonstrating, you click on these and it jumps to another world. It was never part of the visualisation itself.</td>
</tr>
</table>

	48e) Could the user go back in time? (like the undo feature or movie player) **AC: Could the user go back in time in the sense that you might use an undo feature on a computer?** KF: You could reset the world. There are only three functions in it.	*48f) Any others you can think of (describe)?* **AC: Would there be any other mode of interacting with the information, you mentioned random which I hadn't got on my list?** KF: No, It's a fixed path but what I meant by random what that the way in which buttons was created and placed was randomly created it boiled out and we threw away the pieces that were not of relevance there used to be a lot more on there and we got less and less you know we had a whole telephone with all its functionality on the screen and it wasn't relevant because we weren't modelling a telephone we were modelling a service. We only needed enough to get across the idea. We didn't need the flex and the display and the tilt and the display it was pointless. **AC: Was there a process by which you took things away and thought that's important and put things back?** KF: No, we started by trying to visualise the real thing and realised that wasn't working and started again and binned all that and did this.

49) What was the reasoning behind the modes of navigation?

AC: What was the reasoning behind the mode of moving through the information?

KF: It was purely the logical sequence that was being show in the brochure the explanation brochure, so we tried to mimic exactly the sequence that was being shown in the brochure.

AC: Did that constrain it in any way or was that useful?

KF: That was the only way anyone had of understanding the services I didn't understand it from any of the other things I read but I did from the brochure that human factors had produced the instruction leaflet.

50) Did the interface demonstrate structure or relationships between entities or information?	*50a) If so, how did the 3d differ from the 2d for conveying this?*

51) Kineasthetics - How did the user relate to the 'known' aspects to the totality of the interface (i.e. how did users understand where they were, where the edges were, where they had been etc).

AC: In terms of what has been described as kineasthetics, this relates to how a user who was using this understands where they are in terms of the potential of the space their notion of space,

KF: It really has no intentions to do anything like that this the intentions of this were to have an easy way of doing an animation, and out of it grew the fact that it was actually a virtual world any other things pretensions that virtual worlds have since then weren't even contemplated then. We were still exploring the medium, prior to this they were doing kitchens with doors opening.

AC: The user doesn't really explore the space?

KF: No, we were using it purely as a cheap animator. But, after that we realised some of these things, but they weren't applicable to the problem we were trying to cure. Amanda's demo uses space better.

Animated content

<table>
<tr><td rowspan="3">52) Describe the animated aspects within the interface: i.e

AC: Animate parts there is the animation what different aspects does it show?

KF: There were two or three aspects, that a button is activated, a call arrives and that a call sits somewhere and keeps going on ringing until it is answered. Which currently is only a sound and then when it answers it changes state which you don't really get that it drops from a-b the third thing is that we added the mouth to it as it is a person, it's not a line between two points it's a person talking to you. And the third thing we added, I don't know if you got it there, was a bit of slip to it, when you put the call down it drops down and talks when another call comes in, we added fun to it as well, but we also, when you change and put it on hold we gave it another state, but you watch it when we move it, it slides across. And the reason behind that was that when we didn't put that reality reaction in it, it looked dead it looked absolutely dead, and so we put that slide and resistivity in it. So as you slide it around now they actually slide around on the tray, and that made it so real. Compared with them staying in a fixed place. They looked as if they were part of the tray when they were attached to it and that was wrong they were little calls. It's so simple but that animation made all the difference. It actually came by accident. Now that people understood and the fact that it drops away.</td><td>52a) Changed scale?</td><td>52b) Human characteristics?</td></tr>
<tr><td>52c) Emotion?

AC: It has human characteristics would you say that it has emotion?

KF: By accident that little shrinking one. We were going to give it more emotion but it had enough the fact that it was shrinking and dying away and we didn't have to say that that was consistent.</td><td>52d) Mechanical properties?

AC: Human or mechanical?

KF: O' they were human. It was a call and a call was a person not a link between two places. Flogged that thing to death but.</td></tr>
<tr><td colspan="2">52e) Other features, describe?</td></tr>
</table>

53) What was the reasoning behind the form of the animation?

<table>
<tr><td rowspan="3">54) How would you prioritise the purpose of the animation in terms of:</td><td>54a) action</td><td>54b) intention</td></tr>
<tr><td>54c) feedback</td><td>54d) instruction</td></tr>
<tr><td>54e) realism?</td><td>54f) other (specify)</td></tr>
</table>

55) What real world characteristics were employed? (i.e. speed of movement, bouncing, object collision, scale...others)

AC: What real world characteristics did the interface employ?

KF: Gravity, it used resistance you know, slip, and it used cartoon flashing arrows and it used a real handset. The most important aspect it used was sound, you turn the sound off and run it and it is as dead as a Dodo.

56) Did the animation break real world conventions? (i.e. teleporting, fly-through, impossible movements, lack of gravity...others)

AC: Did the animation break with real world conventions?

KF: No, we did have it going up, it didn't work, a call comes in you see and so we had it coming up and then it met one coming down and it all got very confused. So we have always had it just disappearing, the other thing is when the second one came in and you got rid of the call there was one thing I know this sounds like knit picking, doesn't it but, these were quite important when we were playing with it when you did that, you got rid of a call, you could have just made it disappear, and you didn't know where it had gone then, so actually we made a trap door open and it drop and only disappear when it is out of view.

AC: Right so like real world objects don't just disappear they have a path.

KF: It had a path in and it was gone.

AC: And when it disappeared out of the bottom of the screen do you think people just forgot about it then...

KF: Yes, they do completely.

AC: ...So long as it had a path to leave. It went they didn't care to understand where the calls were coming from either.

KF: The person the other end is still there you seen, even though the call was finished, the person hadn't disappeared and they had just moved out of view, and it wasn't thought of like that, we didn't do it like that but we ended up doing it like that because it didn't look right, it wasn't deep thought it just happened, you know.

AC: some things offered themselves as more suitable answers?

KF: It was easy to do on the software. I mean I could have made it disappear but it wasn't doing what we wanted it to do.

Presence

57) How is the presence of the user demonstrated? **AC: The next questions I have relate to presence of the user.** KF: There is no presence, here you are a participant not a present.	*57b) How important was this aspect of the interface?*

58) Did the representation of users (avatars) have real world characteristics? (i.e. speed of movement, human features, physical motor constraints)

59) Did the representation of users (avatars) break real world conventions? (i.e. flying, changing body size (child to adult viewpoints), see oneself, multiple existence of self)

60) Can users leave tokens/objects in the space?

61) Can users pick up tokens/objects from the space?

62) Is the interface a Multi-User Domain (MUD)?

63) How do other people relate to the user in the space (i.e. text windows, visual gesture, speech..)

Visual Content

Overall

64) How would you describe the visual appearance of the interface?

65) Was a generic style intended in the visual appearance of the space?

AC: Was a generic style intended in the visual appearance?

KF: No, it was, let's get this idea together, O' it works and that's it.

AC: I suppose the style you have is based on the facets?

KF: And yes, what was available clip objects we didn't build anything specially for this, the arrow came out of a library the telephone came out of a library of objects it was just how it was configured, in fact that's not true the only thing we did build was the chip to keep the software in, we did have a call store so you knew how many calls you had, but that was never ever really featured, and this had three draws on it.

66) What were the key features of the visual style?

67) What was the reasoning behind this choice? (library of objects, limited user understanding, conventions...)

Process

68) Was it always clear what kind of visual representations should be used? discuss..

AC: Was it always clear what kind of visual representation should be used?

KF: No, it was real innovations stuff, not just me but us playing with it, it's the sort of what you would call a coffee club type thing. Like, how on earth do you represent a call was the biggest thing? Once we had represented a call we had to move it around and as I said a lot of clip art was used and so we used the Lego that was represented in the tool, and this was to be the beginning of moving to the next one. I think it's relevant to see what Amanda did with this.

69) How was the decision arrived at?

AC: How were the decisions arrived at?

KF: I was driving it, I did it, I was the decision maker of how it would have looked.

70) Were alternatives considered?

71) Why were these not employed?

Visual Use of TIme and Space

Time

72) Was time visually represented in the interface?

73) How was the time conveyed:	*73a) Iconically (realistically):*	*73ai) naturally (age, deterioration, lighting),*
		73aii) mechanically (clock, digital watch)
	73b) Did the space have real world time characteristics? (i.e. night and day etc.), give examples	

74) Symbolically: using Logic or conventions? (as amounts, abstract movements)

75) How would you prioritise the purpose of the time metaphor in terms of:	*74a) action*	*74b) intention*
	74c) feedback	*74d) instruction*
	74e) realism?	*74f) other (specify)*

77) What was the reasoning behind using a time metaphor? (creation of belief, technological possibility, organise concepts, other...)

Space

77) How was the physcial space represented visually in the interface:	*77a) Iconically (realistically) -*	*76ai) naturally (perspective, distancing, focus)*
		76aii) mechanically (objects)?

	77b) Did the space have real world visual characteristics? (i.e. distancing, focus, size), give examples: Did this cause any design issues? How were these resolved?	

78) Symbolically: using Logic or conventions? (road signs, co-ordinate geometry)	*78a) Did the space break real world visual conventions? (i.e. impossible shapes, sizes) give examples:*

79) Did this cause any design issues? How were these resolved?

Referents

81) Where have the visual cues been derived from:	*81a) Real world objects - natural, mechanical, digital?*	*81b) Symbolic meanings using convention?*

82) Were some aspects easier to represent three dimensionally than others? *Give examples - from:* **AC: So were some aspects easier to represent three dimensionally than others?** KF: Yes, a Telephone rather than a call or a piece of exchange software - Telephone was a doddle.	*represented easily:* **AC: So the ones that were easier to represent were the ones that had real world counterparts?** KF: Yes, definitely.	*represented with difficulty:* **And, in making the ones which didn't have real world counterparts, how did you go about that?** KF: You started with a cube, and if that worked you were ok and if it didn't you had to add a bit and that's why there's lots of cubes in there.

83) How were these issues overcome (use of different form of representation, change to 3d representation).

84) In what ways does the interface behave similarly to its referent? (has textures, gravity)

85) In what ways does the interface behave differently from its referent? (changes colour, changes form)

Realism, symbolism (icon, index, symbol)

86) How could the interface be characterised using iconic, indexical and symbolic representation?

87) Is the interface mimetic?

88) What is the motivation of the signs? highly motivated/ motivated /not motivated

89) Where did the codes for the symbolic aspects come from? were they deliberate?

Metaphors

90) Were visual metaphors used in the interface? if so were these metaphoric or simile

91) Were the interpretants paradigmatic?

92) What was the purpose (message) of the metaphor?

93) Was an explicit choice made to use this metaphor?

Metonyms

94) Were visual metonyms used in the interface? were these metonymic or synecdoche?

95) Were the interpretants syntagmatic?

96) What was the purpose (message) of the metonym?

97) Was an explicit choice made to use this metonym?

Mental models

98) What were the main codes which conveyed the information (3d/2d/vr/desktop)?

99) What mental models were employed to link the visual information on screen? How could these be described?

AC: If we talk about mental models. Do you think that mental models were used to link the information on the screen?

KF: This is all about mental models, there were no consistent mental models for call waiting and I believe it's a bit presumptuous, but those people who have seen this model remember it. And it was a dawning to us that were playing with it that this was really visualising mental models and that was what it was all about.

AC: Was that something that came about as a by-product of it: it wasn't intentional at the start?

KF: It was a by-product. And then It became the driver for a whole raft of work, mental models were the sort of a buzz word then, they had always existed, I mean I worked on them on pagers, but I never had the ability to animate a mental model other than in my head and this gave me an ability to animate mental models for others to see.

AC: So when you were creating this one were you creating your own mental model?

KF: No, I created the mental model and then built it, and then building it showed constraints and so I, it reflected back. I would say.

AC: And then the mental model changed?

KF: Yes it did. I think the problem with the mental model was that it didn't have, a, a mental model didn't have, any bounds and this doesn't have any bounds, but at least this has a horizon your model didn't have any, it wasn't, it sat in space didn't it, it doesn't have any horizon or position, in your head.

AC: And you say that was a problem, in what sense?

KF: Well to begin with we put this in a box, because it didn't feel right having it sitting out in the infinity, do you see what I mean, you went to call waiting and then you opened the door of a box and there was call waiting in it, and that was what we did originally.
We didn't need the box, it was irrelevant but we did lots of work it's like the simple things left behind but we have thrown all the garbage away, I don't think any of the early models exist.

100) Was the interface also intended to function as a mental model for the user to consider their future actions? If so in what way? Was it successful?

Conventions

101) Is conventional wisdom being employed? (computer interface conventions / social conventions)

102) If so what kinds of conventions were considered to be used?

Floating Signifieds

103) Do there appear to be floating signifieds? Are there ambiguities in the interface?

AC: In semiotic terms they sometimes call that Floating signifieds where you can float words.

KF: Yes, yes I don't know that term.

104) Is text used to anchor meaning? why?

AC: Is text used on there to narrow down some of the meanings?

KF: Yes, last call time.

AC: Was that obvious when that would be used?

KF: Yes, blatantly obvious.

AC: Are any of the objects named specifically?

KF: No because we used them to mean anything like whoever you were talking to.

KF: Not ambiguity, No ambiguity every thing had to be explicit but what it didn't have to be was specific, the other one is highly specific.

105) Is denomination used to describe meaning? (are objects named)

Audio Content

Overall

106) Was a generic style intended in the audio interface for virtual world?

AC: If we could just talk about the audio side of things. Was a generic style intended in the audio content?

KF: No, it was what was available.

AC: Is that pre-canned stuff, clip sound?

KF: All pre clipped sounds. Yep.

AC: Did they have their own particular generic style that you could describe?

KF: No.

107) How could this be described?

108) Was it clear what kind of audio cues should be used?

AC: Was it clear what kind of audio cues should be used?

KF: Yes, it was blatantly obvious. First of all, the phone ringing and the second was the sound that came from the system when the call waiting was working. Yes.

109) How was the decision arrived at?

AC: But as you mentioned before there was a difference between sound that the actual system

KF: We used the sound the system did and it didn't mean anything, and so we put in a sound attached to a moving object that did mean something and a lot of people who saw it said they wished it did sound like that on the system because then I would remember the mental model and they used the sound as a mental model trigger. And we asked the exchange if they could put that sound on instead of the current sound and all the exchanges around the Country don't have the ability to put that quality of sound, they do, but you would have to use a sort of pre-taped or stored memory instead of just sending a signal to a tone generator. 'Boing' was a multiplicity of sounds, isn't it, not just a tone.

110) Were alternatives considered?

AC: So, different alternatives were considered earlier but the final one..?

KF: Only once, we used the original tone, I think we spent ages trying to record it and it was pointless.

AC: Is that the only sound that is involved in the interface?

KF: There's two sounds the ringing is American ringing, yes, because it came with the phone, its not British we tried to bring sound in but I didn't have microphones I didn't even know how to get that in at that time, I do now it's a doddle.

111) Why were these not employed?

112) Where have the audio cues been derived from? reality or convention?

AC: Would you say that the audio cues were from real world or from convention?

KF: Real world, O' both, the 'boing' was convention, the ringing was from real world. You could have used an awful lot more sound and Amanda did, it's lovely she used a lot more sound, it adds to it.

113) Does the interface behave similarly or differently from its metaphor?

Audio Use of TIme and Space

Time

114) Was time audibly represented in the interface? what was the purpose of this? (creation of belief, technological possibility, organise concepts, other...)

115) How was the time conveyed? **a. Would you say that the audio cues were from real world or from convention?** Real world, o' both, the boing was convention, the ringing was from real world. You could have used an awful lot more sound and Amanda did, its lovely she used a lot more sound, it adds to it.	*115a) Iconically; naturally, mechanically (sound of clocks, bells)* *115b) Symbolically using logic or conventions? (beeps as with computer conventions)*

116) What value did the audio time metaphor provide: action, intention, feedback, instruction, realism, redundancy? other specify

AC: What value did the audio give?

KF: Vital.

AC: Was it kind of action intention feedback instruction realism,

KF: All of those, all of those, it was remarkable, you see this thing without the sound on, on and off, and the difference is four times better with the sound on.

AC: Why do you think that is?

KF: Because we are multimedia human beings and I was using real world things all of a sudden there was a phone ringing and that wasn't ringing, once you put the ring on. It became more real phone. When an object was hitting another not making any noise, once you made it make a noise it became more real.

AC: Do you think it was more important to have sound with the concrete real objects then because they had sound in the real world? Perhaps less important for the ones that were abstract anyway.

KF: Yes.

KF: The abstract had very little than being a cube by using sound you could actually give them a function, like I've got some in the emotional icons spikes you hit them and you stop, your viewpoint stops but the sound goes 'dooing' metallic, if that was a squish it wouldn't be applicable.

AC: In a way, squares don't bounce, but with a sound they sound round.

KF: Yes, maybe you are reading more into it than I am. Yes, we did do round ones later, Amanda turned the calls round.

117) What was the reasoning behind the form of the time metaphor?

Space

118) Was the sound three dimensional? stereo? **AC: Was the sound three dimensional?** KF: Yes, but that just came with it, It wasn't used.

119) How was space audibly represented in the interface? **AC: The sound wasn't used in any way to orientate you spatially?** KF: No, because you are fixed viewpoint.	*119a) Iconically : naturally (distancing, material sounds, animal sounds), mechanically (sound of objects)* *119b) Symbolically using logic or conventions? (doplar)*

AC: Is there anything else you want to mention about sound?

KF: It surprised me, I thought everything was visual and when I came to do it the most powerful thing that was added to it was sound and In fact that lead us into having our own sounds designed for other systems Amanda and I commissioned a musician to write our own sounds for the next version of call waiting, and we've got a library of them.

AC: Do you think that the interface would have been effective as a sound only interface?

KF: They tried a sound only, I think, in the past, because it had to be speaking and then noises and it didn't mean a thing, so it was both.

Users

General

121) What was the previous knowledge of the intended audience, could this be specified:	*121a) directly, indirectly or by customer profile?*

122) Were the intended audience expected to understand particular conventions:	*122a) Computer, designerly training i.e. dtp/3d, office environments, home environment.*

123) Were user mental models employed?	*123a) What user mental models were employed?*

124) Were the audience perceived to have similar cultural values and codes to the designers?

User Trials

125) What user trials were undertaken?

AC: I have got some questions to do with user trials were any trials actually undertaken with it?

KF: Not officially, a lot of people have seen it, both Amanda and myself and the project manager had gleaned opinions and whenever I have shown it at a big conference we have had an amazingly consistent reaction to it, in my opinion not being a forum moderator or anything, but they seemed to me to be very consistent reaction to it.

126) At what stage(s) were these trials undertaken?

127) Did the user trials suggest that the users reacted as the designer had expected?

AC: What sort of reaction was that?

KF: I could use this to explain something else, they came away with o' I didn't know it worked like that, O' I understand, and the other thing was I never thought of a call as an object before, that was the one that was mainly BT internal and now people talk about a calls as an objects. But I don't think it totally stemmed from this, I think it was time when several people were thinking like that, do you know what I mean, lots of people come to the same conclusion at the same time. I think it was a way in which people were storing calls, forwarding calls, manipulating calls, there was a, just after this there was a student at central school who designed that answer phone, real answer phone, made out of balls after this and before Amanda did hers, version of it because it was probably a year between this and Amanda doing her version, a guy called… I want to try and give him credit.

AC: The other chap who did it was Durrell Bishop.

KF: That was three, four years later at the Royal College. I've got his work and I would like to give him credit for it because he did come up with it.

AC: Do you think that the people who use it would need to understand computer conventions?

KF: No, no.

AC: They would be relying on real world conventions perhaps?

KF: Things they picked up from a kid. That was the whole premise of emotional icons it was to go across culture. Just like lifting an eyebrow on a Disney animation, round the world whatever the age they would understand, no training. That was behind emotional icons I'm not sure that would apply to call waiting, but some of the things in it came from.

AC: Would the audience perceived to have similar cultural values as the people who designed it?

KF: Yes, yes of course they were I have no other way of receiving cultural values of anybody else other than myself. You could say I tried, but no.

AC: Did, you mentioned before about comparing text version of it to using the mental model version. Was any kind of formal trial done on that?

KF: I think some of the people doing the text version showed it, It wasn't done formally, maybe five or six people were shown it and say is that what you just think, o' yes it is or o' no it isn't, or o' I wish I had seen that before. There was lots of that kind of comment. I can't remember who did it. It wasn't me who was demo'ing it either. Because it was just around it was a demo that just, just.

128) What were the criteria for the user trials?

129) How did users rate in relation to these criteria?

130) What did the user trial reveal?

131) Did this change the design? If so how?

Pragmatics (Marcus 1992)

<table>
<tr><td rowspan="3">132) How did users comment on the usability of the 2d and 3d aspects of the design in terms of:</td><td>132a) Legibility (speed of recognition)? [immediacy]</td><td>132b) Utility (ease of use)?</td></tr>
<tr><td>132c) Identifiability (intuitiveness)?</td><td>132d) Memorability?</td></tr>
<tr><td colspan="2">132e) Pleasure of use?</td></tr>
</table>

Findings

133) What do you perceive to be the main successes of the project?

AC: On to the conclusion parts now, what would you perceive to be the main successes of the project?

KF: It kept me funded that year, (laughs) no, one is that it was used totally out of proportion to the amount of time that it took to create it. That it led on to Amanda's work, and Amanda's work did change the way that telephones were laid out, to reduce confusion for customers, that was a spin off. The other one was that it made people think a whole lot more about what we could do with a screen phone, because up to that point they had been duplicating in text on a screen phone and the first ADSI screen-phones were all text phones which weren't addressing the problem. And I believe it was one of many projects that pushed people, many projects, pushed people towards a graphical 3D way of using services rather than text based way of. So, it was like trying to get a GUI onto a phone. It was one of the things that helped push a GUI onto a phone.

AC: And a GUI is?

KF: Graphical based user interface instead of a text based user interface.

134) What do you perceive to be the main shortcomings of the project?

AC: What would you perceive to be the main shortcomings of the project?

KF: It didn't get an owner, in the business where it could have had an effect. And the reason was that wasn't the aim of it initially, but for the company to benefit from it it needed to have an owner other than just as a research demo.

135) Were any guidelines discovered through the project?

AC: Were there any guidelines promoted through the

KF: No, I think it is a very closely knit field that we are working in, people who could influence saw it, that's all you could say, there's lots of people who know it and that was all it was supposed to do. It hasn't been built into any guidelines. It has put a spin on, I hope, it has just put a spin on the way you look at things, does it the way you look at things? I mean that's what the icons did it put a different spin on the way you look at things.

AC: That leads things forward the thinking of the group?

KF: Or, they don't like it, I, the thing that Amanda wanted to do was completely different which I think was great. But, because before there wasn't anything, now there was one, now you could build something better and different from it but before that, call waiting, there wasn't anything not that I know of.

136) What were the advantages of using 3D?

AC: What would you say the main advantages of a three dimensional were?

KF: Speed, I could generate an animated sequence in seconds by giving something bounce, you try and do that with a set of cells, you know, and I could vary the rate of the bounce so the 3D world was, the other thing was that I could set my viewpoint whenever I wanted if I couldn't see all of the elements that I had built together I could readjust the viewpoint. This was for setting this as an animation we were not using 3D other than as an animation package in this case.

AC: The alternative animating software would be?

KF: A nightmare. It was cell by cell rendering of each cell on a PC probably as wire frame with flat colour, so that's what was around then if you wanted to go to anything more than that then you would go off a PC and you would go onto a mainframe or a silicon graphics and they needed acres of training to get on it. It could be done we had the ability and the skilled people, but this project wouldn't have justified it, it was more important to put that skill onto something different.

AC: And do you think that the advantages?

KF: They are general advantages for visualisation, if you can get visualisation straight out of the person having the idea, rather than via a technician be they a programmer or whatever. Then you can give the creator of the idea the tool and then the other thing you can do is take the time between the idea and the creation, shorten that so instead of having to carve something its there instantly then that's the other advantage. Because then you can then Change and change and change and that's what I found was lovely about doing it and I think that's what keeps you going the tool was non tiring, and highly creative.

137) Do you think these were these specifically related to this project or more general findings?

138) What were the disadvantages of using 3D?

AC: What were the disadvantages of using 3D?

KF: The user interface was rubbish, and you as a designer wanted to spend your time redesigning to the interface. And what was really funny was I was trying to design easy to use interfaces on a tool that had a terrible interface, it was a certain irony that the tool was appalling bad laid out but had the functionality that I wanted. That was the frustration.
It wasn't consistent was the upsetting thing, I don't mind it being bad or difficult to learn but when the thing wasn't consistent in its abuse, when it got things wrong it got them differently. You were 90 percent of the way there and then it didn't work.

AC: Do you think that...

KF: The tools have improved, out of all proportions.

139) Do you think these were these specifically related to this project or more general findings?

140) Were any guidelines promoted or documented through the project?

141) Were any distinctions made about the virtues of 3d in the project documentation?

142) Were any distinctions made about the constraints of 3d in the project documentation?

Method Shortcomings

143) Were there any shortcomings in the way the project was carried out?

144) Were there any advantages to the way the project was carried out?

Recommendations

145) What recommendations were derived from this project?

146) Were any patents created as an outcome of the project?

AC: And Patents are the other things that I haven't mentioned.

KF: It was early days in those days. We didn't really think about those things. Patent was a spin off and was a very useful spin off to say that we have a deliverable, alliances with anybody else we thought we had got an edge and we weren't going to give it away to anybody. Not until it was patented and then we could talk about it.

Concluding Remarks and Recommendations for later interviews

AC: OK I think that that can conclude.
AC: I know it is kind of running on while it is fresh in our minds it might be work having a quick chat about process in terms of questions in terms of the timings.
AC: I don't want it to be self-conscious. We originally suggested that we would start at one and finish at half four.
KF: We started at two.
AC: And it is five o'clock so we are ahead of...
KF: It's quite a long time.
AC: It is a long time.
AC: One of the things that I was originally planning to do was to divide this up so I would maybe get you one morning or an afternoon and do the first part, the bits about where its come from and who's involved in it and I could then take that away and look at the background information and everything else and do the middle bit as a discrete bit so we could bring this middle bit down in time. So that it doesn't get laborious.
KF: I didn't feel it was laborious it may have been a long time, what I did feel was that it wants to be done a bit more privately than this, so you don't feel as if you, to do it, and then you can talk on and make comments. With regard to the demos and being able to see the demos, because it's all visual and you're doing a lot of verbal, I'm trying to do a lot of verbal explanation that a lot of visual stuff could do, because that is what it is about.
AC: Right OK, so you would rather talk it through more with showing? Do you think that the questions lead into that kind of description or do you think there is a different ways of phrasing them so that they will lead us?
KF: I didn't find any problem with the questions, other than time, I can't remember, I don't have all of the documentation, do you know what I mean, I'm not sure I'm telling the total truth. It may be, look a wonderfully planned programme in hindsight but in fact what actually happened, I can't put the sequences in, you are not necessarily getting the truth you're getting what was the perception after the event.
AC: And the later case studies will be clearer because they are more immediate.
KF: And they are well documented this was quite quick.
AC: And in a way it was a lovely visualisation and both of them are very interesting. They are nice because they are abstract and I like that aspect that they challenge some of the mimetic aspects of the interface. But at the same time because it is a historical thing, its quite a small project and all those things, we can use it as a pilot study and we can still use the information from it but it is more sort of.
KF: I don't think we would have got to where we are now unless we'd gone through it as a project. And a lot of what is going on in other projects I honestly believe is they are still behind us because they haven't putting the virtual chair into the virtual room and the virtual handset and found out that it wasn't relevant. There's an awful lot of people still doing that, now, the fact that I am working on putting carpets and curtains into a virtual world. I'm not knocking it I'm just talking about in my case you are buying carpets and curtains but to put a phone in wasn't relevant, you know what I mean.
AC: OK, so are you happy with the questions as they are?
KF: It's just that it's quite a light weight project to put that on. I don't think we went that deep even in the pub.
AC: Some of the middle bits I picked out questions because the questions here are very in depth for example I have tried to highlight the questions that were really, really important ones but here space I have broken it down like space and time representation in that because is not a three dimensional world it wasn't relevant.
KF: Time was relevant you know when we hit the button and the call disappeared it then because one had disappeared the exchange rings you back, we could have had it instantly, once you did one thing and some, the other happened, but we actually had to put a delay there, right, because the software would have allowed you do it instantly, because once you did the thing ringing you wondered whether it was the one that had just gone, not the new one, that was, time was used there quite a lot, sliding of that thing, it could have just jumped, we used time quite a lot, you run it on a fast machine and it doesn't work as well, because it renders quicker and everything happens quicker and it doesn't work as well so I think time was important, it was important
KF: Its like when you run my icons on a fast machine they look super agitated whereas on mine they just go gently and then just nervous or a bit worried or a bit calm. So you have got to watch it on that, it's not what you meant by time is it?

AC: Well I don't know I think the questions that I have got, I think that there are time issues that can be discussed, but the questions that I've got are me trying to dissect and cut up

aspects of time, so I don't know whether these would left us trying to force the interface into the questions.
KF: I think it would because they weren't considered until we tried to, they weren't considered in the building of it they were artefacts that we were dealing with during trying to get it to work once we had built it, so we got all the artefacts in and didn't consider time at all, until we ran it and then O' time was a problem and so we then played with time. But they were never considered in the building of it.
AC: One of the things that I will do with the same questions is I will look at the interface in my own time and try and see, as objectively as I can what perspective I will take on this and there may be an opportunity to ask Amanda some questions also and start to compare all of them.
KF: I'd love you to ask her because I'm sure she has got a completely different view of it.
AC: The only way we can confidently say these are true is if we have some kind of consensus around the documentation and interviews and everything else.
KF: You will get more of that from our other projects rather than this because there were more people involved more exposure. But this one will be a test, talk to Amanda and see what she thinks.
AC: The aim of the project research is to dissect them out but again it is not to falsely invent them in the process.
KF: I think I have got to be careful of because in the hindsight of what we have done since, then yes I have considered them and I can't falsely say I considered it at that time. I didn't.
AC: That's qualitative stuff that should come through from the interview questions.
KF: There were a lot of things that we did consider, but...
AC: I think that one of the original things we said about all the projects that they were done as a suck it and see approach and...
KF: Intentionally. Yes.
AC: That these evolved iteratively, does that make sense, over time.
KF: All of us have worked iteratively for years and got...
AC: To reflect on it and to try and draw out some trends that would be useful to build upon so I don't think we are expecting theses things to be present then in any sense but if we can try to draw them out now in a reflective sense then that might be useful so it might be you saying that was definitely not there, that was definitely there.
KF: Were done.
AC: Do you want me to leave this with you or are you not going to have time to look at them. Do you feel that the questions are coherent enough?
KF: I'd hang on to them because one of the things is I think they should be a surprise every time rather than spending hours cogitating about o' yes I really did do that or didn't do that. Or trying to pre-answer them or order that my answers, that's not what you want.
AC: What I want is to hear your view and for these to spin off thinking, not to answer the questions for you.
KF: One thing would be to say I am a third of the way through I'm half way through, I'm two thirds of the way through, I'm three quarters of the way through, while you are going through it so you have got some idea of Is this going to go on for another hour or half an hour? Because it won't just be me you will be Amanda and the others, Mary.

APPENDIX 5: RAW DATA FROM VISUALISING THE FUTURE FORUM IN BT

27.11.97 BT Laboratories

An expert forum was held to consider the issue of three dimensionally in Human Computer Interface design.

Agenda

1. Introduction

2. Laptop Presentation

A presentation was created which represented the issues addressed by the research to date, this presentation was intended to focus the discussion and if necessary add any additional areas of interest to the debate. To maintain the objectivity of the process, this presentation did not represent findings of the research project, yet would reveal the assumptions upon which the research was being undertaken. These would fall roughly into two categories research assumptions and research questions.

2.1 Research Assumptions

The research assumptions represented the explicit choices made by the research which allowed the subject matter to be defined and the questions to be raised. These were initially explained using examples and references in the presentation.

Here is an unordered list of the contextual assumptions:

- Perception is creative, based on mental models of learnt signs
- Language in all its forms alters the way we consider/see the world
- We have a range of mediums at our disposal
- Different mediums bias the production of meaning
- New technology has facilitated the development of a new, three dimensional media
- Three dimensional media have specific attributes

2.2 Research Questions

The research questions were aimed to focus the discussion, relating to the kinds of questions the research had addressed. Here is a list of the questions raised:

1. What is the three dimensional medium?
2. Can we use an understanding of other media to gain insight into what three dimensional media has to offer?
3. What contextual issues surround this new medium?
4. What might its benefits/constraints be?
5. Will it open up new knowledge?
6. What are the implications of not addressing this?
7. How should this issue be pursued in the future?

3. Equipment

- presentation techniques
- seating arrangement
- Dr Young's voice conference

4. Order of day – Speakers' positional statements

A formative list of issues and questions was recorded by the researcher under the direction of the experts. This formed the conclusion to the main discussion at the end of session two. This was considered to reflect the main issues from earlier discussions.

RAW DATA TRANSCRIPT NOTES

Morning Session

Greg Rowland (Communications analyst)

Consumer doubts about what has seemed to be a gimmicky three dimensional as popularised in the mid 1980s through virtual reality, and which currently resides in a video game language.

Martin Woolley (Professor of Design Studies Goldsmiths College)

From a practical three dimensional material background - wood, metal.
Researched for PhD in the relevance of the Micro-chip to design.
Interested in consumers making sense.
Chair of the National Association of three dimensional design.
With the three dimensional there are attributes missing: what does that mean to three dimensional reality. Semiotics history has been mainly literary. Also interested in the symbolic nature of the three dimensional imagery. What are the real benefits?

Gunther Kress (Professor of Education: English Curriculum.)

The English curriculum relates to communication and culture, if this relationship changes what does this mean for the future? Choice of systems of signs. 1988 Social Semiotics. However Multi-systems of culture (where the power resides). The visual is a system of regularities. Different modes have materiality, the image should be considered in terms of the properties of light as speech constitutes sound. There are differences in that the speech is temporal and sequential, whereas the visual is spatial and simultaneous. The three dimensional would seem to represent the non linear such as the hyper-textual. What are the affordances of three dimensional, especially when it is still two dimensional?

Harold Thimbleby (Computer Science)

Degree in physics followed by a professorship in a psychology department: looking at computational vision. Interested in making computers easy to use for people. This might be achieved by looking at psychology and social problems. Driving forces are metaphors.

Distinctions:

- Material three dimensional
- Perceptual three dimensional
- Kinaesthetic

Immersion:

Gestalt theories

- Figure - held (cup within room)
- Ground - hold (room)

2D Discourse:

- Voice - amplitude and time, transient and informal
- Paper
- Screen (hence flames)

The above have emotional values.

Drama:

- Media = Reality as Reeves and Nass suggest we do not distinguish between the two, 'the media equation', we therefore treat computers as social creatures.
- Edges (2 and 3d) do you forget the edges
- Stage effect - when actors leave the edge of a stage and start other realities, this doesn't affect your perception of the reality.
- Demos - salesmen make a stage from which to sell a telephone.

Computation:

- 3d and 1d formally computers can do things in all dimensions.
- The advantage of the three dimensional is if it is fast. If it becomes faster than our perception then it doesn't matter.
- Feedback

- Equal opportunity

Edgeless Interaction:

- Ubi-comp (Ubiquitous computing). In three dimensions a fax is 'there' (a spatial dimension) however in reality it is a 10 dimensional number.

Etceteras:

- 3d texture, stereo, solid(ity) don't need to see in 3d to get the illusion.
- 3d is not only Euclidean
- Planarity (hyperlinks can be flattened into planes of information).
- Just reality (should do better, enhance, not just simulate it).
- Metaphor
- Film D.W.Griffiths shows in film what has not happened yet in computers. It is still limited.

<u>Robin Baker (Ravensbourne College of Design and Communication)</u>

Trained as a three dimensional industrial designer, then took a degree in computing. It became clear that there was a world of values of design and of computing and that these did not mix. The question as an educationalist was how to join the two cultures (which took place whilst working at the RCA); this resulted in the setting up of an interface design course, however the question remained - what elements would need to be taught.
At Ravensbourne design was about interpreting technology in a creative way.

RAW DATA DISCUSSION:

RB: Is imagery a language? (From the agenda issues to consider). Is there a three dimensional language? New paradigms should come from design professions. Ways of looking at interaction.

MW: Language - Initially designers were seen as encoders of information which is then decoded by users, yet this soon falls away under scrutiny. Designers build some things. Who's speaking it and who understands it? Classify responses to compare (crude), but it highlighted the areas of definition.

GK: Language is already a metaphor - although speech and writing are totally different. Using the term language carries forward all the baggage from the medium. Potential of forms of communication - communities of speech impaired use gesture (not language) to do all the things communities need to communicate. What does this do with the brain - affective and cognitive abilities (as suggested by Oliver Sacks) leads to different. Translation between them - The visual can be full communication. However we don't teach it as communication (art is regarded within aesthetics).

RB: Reject limitations when necessary i.e. the progression of thought from the horse-less carriage to the car. These are moving metaphors. Interaction design is moving towards things.

HT: Boundary: visual languages which are hardwired. We should take advantage of the hardwired aspects as well as the flexible aspects which allow change.

GR: Mimetic properties set up 'promise' as in Star Trek etc. The metaphor mimetic seals of imagination. Looking at Kant, where does that take 3d... 'nice to do things'? Free flow versus stability.

MW: Language is on the one side protectionist and of the other side flexible.

KF: From the background of product design and far futures, much interface is very poor. The opportunity of this research is to visualise things that couldn't do any other way. Not visualise perfectly a glass, but use the example of representing market traders. In the BT work the futures department had used animators to create the meaning, which still worked even with the sound off. The Emotional Icons work was one such example, where data has attitude. This is therefore not three dimensions for the sake of three dimensions. An analogy in history would be the use of plastic to represent ivory and ebony when, even under these circumstances it still remains plastic.

GK: It would require us discovering the affordances of the medium. Children's drawings show information which is unlikely to exist in any other form, and which would not be translated into language. Curriculum, managing information in three dimensions. 3d is not non-metaphoric even if it reflects reality. Language can not actually say all.

HT: The author is not in control of the way an image is read. When reading a novel which is represented by black marks on paper, the author does not control the way the reader interprets the information.

MW: The key is control, often we aspire to the photographic and then move on from it.

HT: Virtual Reality.

MW: The fear of the loss of intellectual controls as the power can control.

KF: Use 3d in right order for body.

GK: Different cultures privilege different modes of communication, there forms a rank order.

RB: Are we in a highly visual form, is the western mode visual?

GK: We are mainly spoken.

HT: Rectilinear culture: see things

GK: Aural culture is not less developed but different. Training ears and memory in visual culture are different.

KF: Technology can break away from audio and text, our children are learning through 3d visual interaction. The generation gap means that we missed it. Technology has allowed freedom.

RB: We couldn't have had this discussion 10 yrs ago.

KF: Can read 2d >> visual language.

HT: Are we on the edge of something exciting. In the historical transition from voice to written the written had an accuracy. Early written scriptures had religious significance, written in stone. It was only after the invention of the printing press that people could analyse such writings, such as that of Aristotle, where the mistakes could be seen. This moved thinking forward. That which was once idolised was destroyed and questioned. Currently the 3d is hard to create.

KF: We are on the verge of that not being true.

HT: Value systems will have to change when it becomes easy to make 3d. Whereas looking back it may seem obvious, but at the time it was not clear what the progression would be.

RB: What are we on the edge of?

HT: People in history cannot see the future. They often call it coincidences but these are occasions which are actually quite systematic.

MW: One thing which has happened in history is that we have been concerned about the loss of memory skills, the skills for recording. Manipulating memory.

RB: Meta-memory.

GK: We do not know what we are on the edge of. 1000 year old cultures. Epochal change - industrial changes lead to the information society.

Globalisation...will cause cultural mixes rather than cultural stability.

Language decentred. Complex economic, social, cultural and educational. New age of 'hieroglyphics'

HT: A pessimistic view would see the drive behind the future to be mass market multimedia entertainment (aside from the military).

KF: This was the case three years ago, now we are looking to integrate systems, customers, customer.

MW: It seems to be the business of reducing effort, reducing intellectual effort. Do we have to spend effort to get something.

GK: The Barings Bank scenario couldn't have happened without the particular mode of representation.

HT: All doing same call processing.

KF: Less data more knowledge.

GK: Different kinds of effort, Knowledge > Information.

HT: Wisdom.

Afternoon Session

BY: Designers pick up on the technologically determined approach ....

GK: Human centred has been something mentioned here. However it is a multifaceted approach: considering cultural mixes reshaping themselves. Human interest - Seeking human interest within a social, economic, cultural and educational moves.

GR: Subject within the three dimensional is movement. Video games have an ease of use which allows us free movement. Sticky and slow movement kinaesthetically changing perception of self ... especially.

BY: Individual rather than shared. Protocol and forms of behaviour. Technological topicality.

KF: There seem to be centres where we can do this well but it is not ubiquitous.

BY: Semiotic elite. In the past education could lead to self betterment, now we seem to have the technological haves and have nots.

MW: Perhaps we should be referring to 'technologies' not technology, to suggest a range of devices, a pooling of technologies. Society as a whole. Pluralistic values of technology.

GR: Semiotic elite rather than class divides i.e. video games cause individuals to form a group of deep structures beyond the social uses of technologies

BY: 'work technologies'.

GR: Non professionals involved in video games activities are learning a different set of rules.

KF: 3d concerns: Dealing with the technology, setting up the systems not just working with them. There are people at BT who have made a career out of reconfiguring technology.

MW: Man has been characterised from animals by our ability to do useless, not valueless work.

GK: Watching children playing computer games they attach a lot of subjectivity: identifying with the character in the game - "I've got killed". Real engagement in the world you only have one lift not three!!!

HT: Questions relate to an ethical side of 3d as it becomes cheaper and quicker. Whereas stealing in the real world has very real consequences, ethic systems...in the virtual we do not have such systems. In history examples like algebra came about because of Islamic policies on borrowing, causing families to adopt people in order to inherit moneys, it became too complex a system and therefore became symbolic. Land owned versus non land.
Internet resource as an economic 'land'. We don't know how our ethics are working.

MW: There are assumptions based around the solidity of the material world.

AC: Physical copies versus the digital copies, if the digital is an exact copy what affect does this have on our value systems.

HT: Electronic cash can be better than a physical i.e. if you loose a key in the physical world you can break into a safe, in the virtual world there is no backup system to break encryption.

KF: The British Government will not allow encryption which can not be broken if necessary.

HT: Human rights abuses.

KF: The 3d has huge potential for technologies, yet it became clear that we were interfacing it with string and bows and arrows.

HT: Peter Landkin suggested that computer windows are the only windows you need training to use.

GK: Why use 3d representation? Representation systems, mimetic. What are we as humans?

RB: Cultural blocks, i.e. in realist painting. Do we think that 'real' is the goal. Based on the baggage from metaphors. 2d/3d multimodal.

HT: Using the phone is hard, designers will make a mess of the interface, the future would be more likely to have agent based systems.

RB: Through the metaphors you know.

MW: Children's games such as Simcity allow you to build your own world the next obvious stage is to live in it.

KF: Children are not looking at history or reading text books in the way that previous generations did. Their way of looking at the world is different.

RB: How to build on culture of non text book?

GR: Own aesthetics away from the perfect mimetic. Linear progress from Wells. Digital aesthetic for its own sake. Two strands: Linear stands of technology and the post-modern.

HT: Classification of activity currently forms work/play/entertainment. Children's books are ideally font size 6 or 7, yet are designed for the adult impression, we should distinguish between the adult and child.

GK: Distribution of work and pleasure has changed over recent times.

HT: Adventure games can be fun / formatting a disk is not why?

KF: Emotion induced by the three dimensional world much more effectively that with the 2d, it provides a depth of information.

GK: We have to understand who we are before we know about.

3d images like sign language, why choose the three dimensional when we have already opted for a less dimensional medium in the west?

GR: Gesture betrays the unconscious, the west keeps its consciousness up front and guarded. Gesture reveals the uncivilised mind.

KF: Body language - ignored and filtered out.

MW: Especially when on courses about presentational techniques.

KF: Body language was one way to reveal a depth of information.

ISSUES AND DILEMMAS

- The relationship between Epistemology and systems of representation.
- Referential Transparency - Can a sign stand for a reality so well that we can not distinguish between the two?
- Where does the media stop - the edges
- Interaction as a core phenomena - what is the new part of it? What is the core functionality.
- Are the affordances hidden - what are they?
- What is the relationship between 3d and 4d media - the four dimensional gives the opportunity to 'travel' - explore/revisit? Time?
- Western metaphors of space.
- Self generated? narrative?
- The role of three dimensional media within culture: Realism through to symbolism? Messing in time.
- What are the ways into the medium?
- The 3d brand? what is it, what do you fill it with?
- Relation to 'land' the consideration of 3 dimensional media as a commodity. How to divide it - 'semiotic/cultural'.
- Utopian and market vision
- The need for the utopian view

- The 3d world (reality) has a relation, ethical etc. to the 3d virtual, what is this?

- Ethical frameworks - no longer 'personal' constraints.

What are the consequences of actions in the virtual?

Greg Rowland

Three Dimensional Paradigms

Virtual Reality	*Post-modern Techno (?)*
Reality	Fantasy
Teleological Progression	Surprises/circularity
Evolution	Revolution
Conscious	Un-conscious
High European	Non-high European
Ultra-realist mimetic	Self-reflective
representation	aesthetic / abstract
Linear narrative	Non-linear narrative

(Simulacra)

Narrative - Subject / Authorship?

Figure I: Illustration from forum by Greg Rowland

POSTSCRIPT: INVITED COMMENTS AFTER

Issues Raised by Professor Robin Baker

Can imagery be considered as a language or at least a logical construct that can be rationally interrogated - is there any evidence to support this from, for example, the history of painting?
Is computing the paradigm shift that we all feel it is and if yes, what are we on the edge of?
The fact that we could not have had our discussions ten years ago must mean something.
What are the elements that should be taught on a course in interaction design?
What does a "weightless" world look like?
What happens to aesthetics when objects become so small (nano-technology) that they cannot be seen?

Issues Raised by Professor Martin Woolley

Three dimensional computing creates a new continuum between hardware and software, between the object and the screen, between the design of the object and the design of the virtual world. The issue of three-dimensionality is often assumed to apply only to the virtual presence beyond the computer screen. From the design point of view I see one of the looming challenges to be the blurring of the boundaries between what lies beyond, on and in front of the IT interface. The holistic and interdisciplinary nature of design makes it an ideal discipline to explore this territory.

IT sometimes provides definitive examples of technology push largely independent of any demand pull (although the latter is admittedly very difficult to predict) and the added third dimension may well be yet another manifestation of this.

Evaluating the suitability of the three dimensional interface for human tasks is going to be interesting and quite challenging area of research - assuming rather optimistically that such research is commissioned in the first place - before, and not after the innovation machine gets to work. As with all other forms of image, the three-dimensional form can be symbolic, imitative and/or abstracted. It will be interesting to explore whether its increasing presence will reinforce existing stereotypical patterns of use, based on familiar symbols and thereby limit what is possible. Or whether it can be manipulated and deployed to complement new realities and yet remain usable by an ever wider public.

It is easier to get lost in a three-dimensional world than in a two dimensional one. Navigation has always proved difficult in CAD software environments and in many three dimensional games. A new and usable approach to virtual orientation is required. In the 'real' three-dimensional world, objects come with a range of properties which are the working palette of the three-dimensional designer. Many of these are already common in the two-dimensional virtual world including; texture, tone, colour, form shape, etc. In three dimensions these properties are augmented by qualities such as mass, weight, volume, shadow, depth, focus, centre of gravity and the concept of 'effort' required to move or support three-dimensional objects. These properties can all be included or excluded in the virtual environment, by the software specialist. The danger here is that the subtle and varied nature of three dimensional design qualities gets lost or is mistranslated. A new hybrid knowledge base, somewhere between the crafts and software development is required in order to distil and reorder three dimensional characteristics in order to provide as rich and varied vocabulary in the new 'virtual world' as already exists in the 'real world'.

APPENDIX 6: POWERPOINT PRESENTATION FROM VISUALISING THE FUTURE 1 FORUM IN BT

27.11.97 BT Laboratories Laptop Presentation

[Slide 1 - Introduction]

Andrea Cooper, Researcher, andrea.cooper@unn.ac.uk

[Slide two - Research assumptions]

One assumption of the research is that we require methods of classifying the world for efficient, unambiguous communication.

[pause]

These we call signs

[pause, the above replaced by...]

As Umberto Eco observed, "the sign is a lie it is something that stands for something else."

[Slide three - Pierces classification of signs with graphic examples]

Icon Index Symbol

[Slide four - three different translations of text describing our creative perception]

Our Ta tir visual Pemandangan phictiur perceptual persepsi radharcach landscape visual aireachtail kita an adalah chosuil is sepeiti le like a helaian leathanach buku clo, sesetengah, page seasann perkara of rudai text, bagar airithe melonjak some things keluar, amach jump out, namun laithreach, semna yet nya ach ta adalah gagh untuk they ata are all scriobhtha there ar an leathnach to ansin be romhat le leamh perceived ditanggap

[Slide five - repeat with coloured sections of text as shown here in bold]

Our Ta tir **visual** Pemandangan phictiur **perceptual** persepsi radharcach **landscape** visual aireachtail kita an adalah chosuil **is** sepeiti le **like a** helaian leathanach buku clo, sesetengah, **page** seasann perkara **of** rudai **text,** bagar airithe melonjak **some things** keluar, amach **jump out,** namun laithreach, semna **yet** nya ach ta adalah gagh untuk **they** ata **are all** scriobhtha **there** ar an leathnach **to** ansin **be** romhat le leamh **perceived** ditanggap

[Slide six - revealed step by step]

Signs

With an ever increasing structure of signs representing experience we are often under the false impression of thinking we know a situation when in fact we do not.

[Slide seven]

Mental models

Mental models are like maps, we carry them around to help us navigate experience.

[Slide eight - revealed step by step]

Mental models

A ship is sailing through the night. On noticing a light on the starboard wing, the captain called to the signal man, "signal that ship to change course 20 degrees"
Back came the signal "advisable you change 20 degrees"
The captain called back to the signal man, tell him "I'm a captain, change course 20 degrees"
"I'm a seaman 2nd class" came the reply "you had better change 20 degrees"
Furious with rage the captain retorted "I'm a battleship change course 20 degrees!!!"
Back came the flashing light "I'm a lighthouse"
We changed course.

[Slide nine]

We can choose / change our mental models

[Slide ten - demonstration of different media types starting with binary]
00100000 01010011
01110011 01100001
01110100

[Slide eleven - demonstration of different media types two, text]
00100000 01010011
01110011 01100001
01110100

Seat

[Slide twelve - demonstration of different media types three, images]
00100000 01010011
01110011 01100001
01110100

Seat

(image of a seat)

[Slide thirteen]

"The medium is the massage" Marshall McLuhan

[Slide fourteen
(image of many different forms of visual advertising)

[Slide fifteen]
New dimensions of reality are opened up to the powers of observation. With computer graphics stations, it becomes possible to 'see' things that are otherwise inaccessible to the human gaze...It is now actually possible to visualise the interior of a dying star or a nuclear

explosion. The mind can go places where no physical being will ever be likely to go."
Kevin Robins

[Slide sixteen - revealed one by one]
Contextual Assumptions

Perception is creative, based on mental models of learnt signs
Language in all its forms alters the way we consider/see the world
We have a range of mediums at our disposal
Different mediums bias the production of meaning
New technology has facilitated the development of a new, three dimensional media
Three dimensional media have specific attributes

[Slide seventeen]
Questions

What is the three dimensional medium?
Can we use an understanding of other media to gain insight into what three dimensional media has to offer?
What contextual issues surround this new medium?
What might its benefits/constraints be?
Will it open up new knowledge?
What are the implications of not addressing this?
How should this issue be pursued in the future?

APPENDIX 7: RAW DATA FROM MULTIVIEWPOINT

Summary of Three Key VR Presentations:

1. Kim Fisher BT Labs, Interaction Futures

Do's and Don'ts of Virtual Reality:

1. Don't use 3D just because you can, because it confuses people
2. No point in modelling a chair that you can't sit on.
3. You go shopping in a real mall in a similar way, virtual shopping should be treated as different.
4. Beware of fly-through vertigo.
5. Peripheral vision.
6. A metaphor too far, a PC a windows a browser then a mall throw away the metaphor and think about users.
7. Builders may worry about VRT VRML standards but users don't
8. Interactive 3D worlds, it is not a story you are telling, in media you can control the story by limiting paths. Don't put paths in VR.
9. Matching the visualisation to the viewer, oil trader has a different way, he can see numbers make sure that you are trying to visualise the things that people want you to.
10. Don't put in VR windows from OS it kills the metaphor.
11. Appropriate detailing, visual human avatars, the abstract hold the illusion much better than the realist.
12. Frame rate, why have a lift in VR? You get more cells in between.

Potential of VR:

Message across eyes, ears, intuition, spatial relationship, audio.
Show things that don't exist rather than modelling a tea cup.
Don't forget sound, the most powerful bit even more than the visual bit but can't use in open plan offices.
Make it fun, if they are really fun people will use it.
Tomorrow's customers have excellent hand eye co-ordination.

Internet allows you to connect without someone getting in the way - Shared spaces

Live modelled world, you get the data to build it live in front of you.

Software agents going out there and finding data, and presenting it to you in a way that you understand - persona

Multiple views on the data

Not representing data but getting around data - Navigation

Jump to other worlds

Change colours, surfaces and see them on the three dimensional model.

Likewise you can check that doors will open that furnishings will fit.

Likewise you can have real clocks showing real time

The objects can have affordances so that if you try and put a chair near a fire then it will jump up and change its behaviour.

Beyond the physical you can view it from a distance.

2. David Roberts, IBM Ease of Use

Choosing the Real World as your Metaphor

The techniques of 3D presentation have been widely used in games, modelling, simulations, and data visualization. The RealPlaces guidelines focus on the use of 3D in a user environment appropriate for personal and enterprise task-oriented computing.

The RealPlaces Guidelines describe a 3-dimensional user environment, such as might be created using VRML 2.0 on the Internet. Such an environment might also be used as a desktop replacement, a potential next step in the evolution of today's GUI interface.

These guidelines are based on two years of iterative analysis, design, prototyping, and user testing. Our intent was to understand crucial issues associated with using 3D techniques in a business application environment where training and productivity concerns are paramount. We share these guidelines with the intent that others benefit from our work, especially the users of applications that take advantage of the power of 3D presentation.

This work places a special emphasis on the use of 3D in an enterprise environment - for doing real work. The issue of productivity has been addressed in all aspects, including the design of the world, navigation approaches, and object interaction. We believe that the extension of 3D techniques beyond the current game and simulation domains into the enterprise environment can be successful if the issues of ease of learning and productivity are adequately addressed.

These guidelines embody and illustrate architectural concepts and relationships. Exemplary and potential implementations are shown but not prescribed. Developers might choose from a variety of techniques to implement a particular concept or relationship.

3. Walter Penndorf, Aka Visualisation Limited (now head of VR at Porsche)

VR as a User Perspective

Identify new tools for the design process and see if they are promising to be integrated into the design process. More realism as they allow us to interact and influence them with different input output. Reality is confirmed by all our senses, we would ideally manipulate all of the users senses. Manipulate objects in a more direct way interacting directly with the model.

Immersive VR

Immersive tries to simulate the whole world and cut out the real world.
It allows us to explore a range of worlds, limited by creative imagination of the designers.
Cost intensive, I have to model everything.

Augmented Virtuality

Mixing real and virtual objects, whatever is there is not needed to be modelled so you can overlay models onto the real. Time and cost saving and how people hope that with the application of VR programs to be able to build less physical prototypes
To perform design changes quicker and cheaper.
And to have a higher density of information as opposed to two-dimensional drawings to make design based decisions.

Applications

Already used in automotive in production and process planning and simulation.
Daimler Benz are using VR for **real time testing** and showing interior design using a CAVE where a person performs ergonomic tests.
Visualise difficult to access data, i.e. Aerodynamic **simulations.**
Parts of a **prototype** to simulate how they go together, where a prototype doesn't exist yet.

C.A.P.E (Computer Aided Production Engineering).

Driving simulator for Chassis simulations.

Marketing and sales, the advantage is to be able to modify change colour without having to have real physical cars in the show room.

As a **Presentation tool:** virtual models on the basis of our 3D modelling system.

Achieve **colour definition** material, **collision checks** for parts, **documentation tool** for different design stages.

As a basis for **digital sketching,** take snapshots and export them into digital sketching .

As a **Design tool,** interactively changing the positions of parts on a design.

Research and development: augmented development, building a mixed mock up environment. Optical tracking system with Brunel University.

<u>The future:</u>

Simpler user interfaces.

Once you see what you can do with a tool you wish to do it simpler.

It is not possible yet to make direct changes with the model.

RAW DATA FROM MULTI-VIEWPOINT: SHAPING THE HUMAN COMPUTER INTERFACE

Kim Fisher BT Labs

I work at BT labs on virtual reality over the internet. Virtual reality home shopping. Personal opinions based on using virtual reality product.

Do's and Don'ts of Virtual Reality:

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14. No point in modelling a chair that you can't sit on.
15. You go shopping in a real mall in a similar way, virtual shopping should be treated as different.
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Potentials:

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Show things that don't exist rather than modelling a tea cup.
Don't forget sound, the most powerful bit even more than the visual bit but can't use in open plan offices.
Make it fun. If they are really fun people will use it.
Tomorrow's customers have excellent hand eye co-ordination.
Internet allows you to connect without someone getting in the way
Shared spaces
Live modelled world, you get the data to build it live in front of you. Data pushes axis on a VR model, so the data turns it into a prickly pear. So he knows a deals shape.
Software agents going out there and finding data, and presenting it to you in a way that you understand - persona
Dreamcast, Middlesex did it plumbed into your fridge.
Superscape, using free stuff, bottom end of the market.
Multiple views on the data
Not representing data but getting around data
Jump to other worlds

Change colours, surfaces and see them on the three dimensional model. Likewise you can check that doors will open that furnishings will fit. Likewise you can have real clocks showing real time. The objects can have affordances so that if you try and put a chair near a fire then it will jump up and change its behaviour. Beyond the physical you can view it from a distance.

Walter Pendorf AKA Design Visualisation

VR as a User Perspective

Identify new tools for the design process and see if they are promising to be integrated into the design process. VR real time interaction with computer generated environments. More realism as they allow us to interact and influence them with different input output. Reality is confirmed by all our senses. We would ideally manipulate all of the users senses.

In this sense why you turn your head there is no delay. Headset, manipulate objects in a more direct way interacting directly with the model. Using actuators at the fingertips to give a sense of forced feedback

Immersive and Augmented VR

Immersive tries to simulate the whole world and cut the real world out to a certain extent, preferably all of it. It allows us to explore a range of worlds, limited by creative imagination of the designers. Cost intensive, I have to model everything. Mixing real and virtual objects, whatever is there is not needed to be modelled so you can overlay models onto the real.

Augmented Virtuality

Play games, medicine, flight simulators, industry and repair (augmented) virtual manuals are used in an aircraft. Assembly training so they assemble what they see on the screen overlaying the reality. Time and cost saving and how people hope that with the application of VR programs to be able to build less physical prototypes to perform design changes quicker and cheaper and to have a higher density of information as opposed to two-dimensional drawings to make design based decisions. Already used in automotive in production and process planning and simulation.

Daimler Benz are using VR for real time testing and showing. And also interior design using a CAVE where a person performs ergonomic tests. Visualise difficult to access data, i.e. Aerodynamic simulations. They are there but we haven't found proper media to show

them yet. Parts of a prototype to simulate how they go together where a prototype doesn't exist yet.
This happens on the basis of virtual prototypes before a physical prototype is built C A P E (Computer Aided Production Engineering). Driving simulator for Chassis simulations. Marketing and sales, the advantage is to be able to modify change colour without having to have real physical cars in the show room.

As a Presentation tool: virtual models on the basis of our 3D modelling system. Achieve colour definition material, collision checks for parts, documentation tool for different design stages. Loss of transparency when in the past you could see sketches in the studio, following the development of the work, experimenting with documenting design stages. As a basis for digital sketching, take snapshots from different perspectives, open the doors. Export them into digital sketching program and continue developments. As a Design tool, interactively changing the positions of parts on a design.

Research and development: augmented development, building a mixed mock up environment. To review interior design. Chrysler, ford, Daimler Benz , the person is in a real seat with data gloves. The hand appears in VR. Seating buck, bring in virtual vision, where you receive the model via the head-set but the touch is real. Optical tracking system with Brunel university. In this we create an algorithm for object tracking.

The future:

Simpler user interfaces. Once you see what you can do with a tool you wish to do it simpler.
It is not possible yet to make direct changes with the model.

Dave Roberts, IBM Ease of Use, Warwick

Choosing the Real World as your Metaphor

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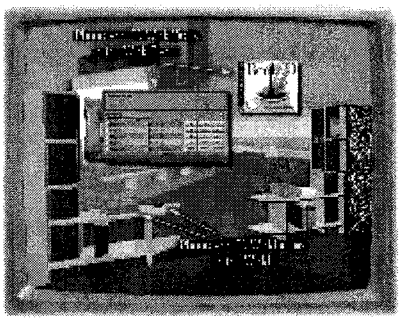


Figure II. Real places

Andrea Cooper, University of Northumbria at Newcastle

Can Three Dimensionality Reveal New Knowledge?

This paper looks at the subject matter of HCI from a philosophical, human centred perspective, it is interested if three dimensionality can reveal new user knowledge. The subject matter is young, therefore, much research to date has been approached from an empirical or technologically determined standpoint. This research is focusing on a human centred approach. It is hoped this will provide a strategic framework from which the medium can be considered. The intention of this research is to facilitate design and design practice by translating often heavily theoretical material into a model for use when designing.

Questions:

What is the three dimensional medium?

Can we use an understanding of other media to gain an insight into what 3d media has to offer?

What contextual issues surround this new medium?

What might it's benefits and constraints be?

Will it open up new knowledge?

What are the implications of not addressing this?

How should this issue be pursued in the future?

Three different means of conveying a message, but what are their individual virtues?

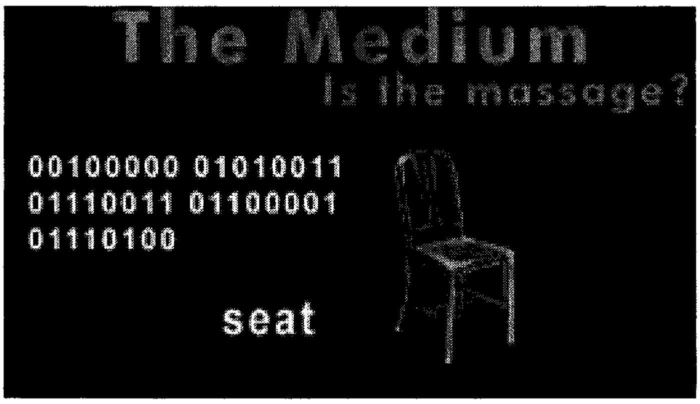


Figure III. Media of Communication

Contextual Assumptions:

Perception is creative based on mental models of learnt signs
Language in all its forms alters the way we consider/see the world
We have a range of media at our disposal
Different media bias the production of meaning
New technology has facilitated the development of a new, three dimensional medium
Three dimensional media have specific attributes

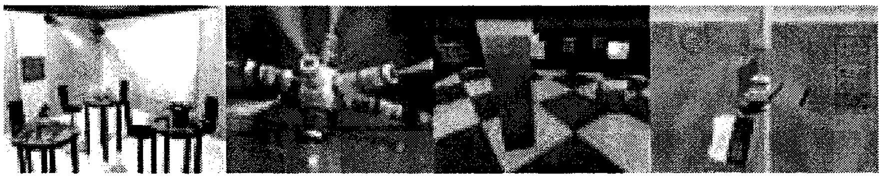


Figure IV. Case Studies

Six case studies were used to investigate the nature of the three dimensional medium: Knowledge=Power, Sculptural Metamorphosis, Emotional Icons, Call Waiting, 3D retail and Concept 2010.

The Value of the Research is to make alternative approaches to design content explicit within a holistic, structured concept of the medium. Create a mental model for designers to employ to support practice and communication of design intent and content to non-designers. Highlight trends in empirical practice. Consolidate and challenge the value of the approach undertaken at BT. Champion the appropriate (Human-centred) use of an emergent medium.

Tobias Misera, Centre for Industrial Design, UNN

Industrial Designer, the New Craftsmen of Media?

New media is a new and unexplored discipline of the arts. New media emerged in the early '70s and comprises sound, dynamic and static graphics, video and text. It can be used for education and training, entertainment, information and presentation, marketing and advertising and it's most important potential; as a composite medium of communication. Advances in information technology have introduced a number of quite significant changes. Firstly, experts from all kinds of professions were enabled to become activists in new media. This however, has gradually resulted in a crisis of identity in which the professional bodies of HCI, cognitive science, psychology, art and design are fighting for recognition. Secondly, the practitioner needs to develop a diverse range of knowledge and skills to fully understand and produce new media. The profession of industrial design has always been aware of advances in technology, whether they concern new production methods, tools or materials. The potential for new media to be a powerful tool was recognised very early. In addition to Computer Aided Design (CAD) tools, industrial designers are increasingly using authoring tools for the communication of the development and product design process as well as for the creation of interface designs. The consequences are that industrial design becomes more complex as it no longer concentrates on the familiar territory of hardware issues but also on interface design. The purpose of this research is to explore new media from the perspective of the industrial design practitioner engaging in a variety of new media projects using action research methods. The objective is to identify the role of the industrial designer as an activist in new media. This will discuss the unique contribution of the profession and whether the industrial designer can be considered to be a director or a producer of new media. The conclusions of this research are based upon an action research process of planning, practice and reflection.

APPENDIX 8: BRAINSTORM & ANALYSIS IMAGES

Contextual Review Analysis

Figure V: Mapping of Issues Emerging from the Contextual Review

Figure VI: Mapping of Issues Emerging from the Contextual Review Illustrating Colour Cross Checking

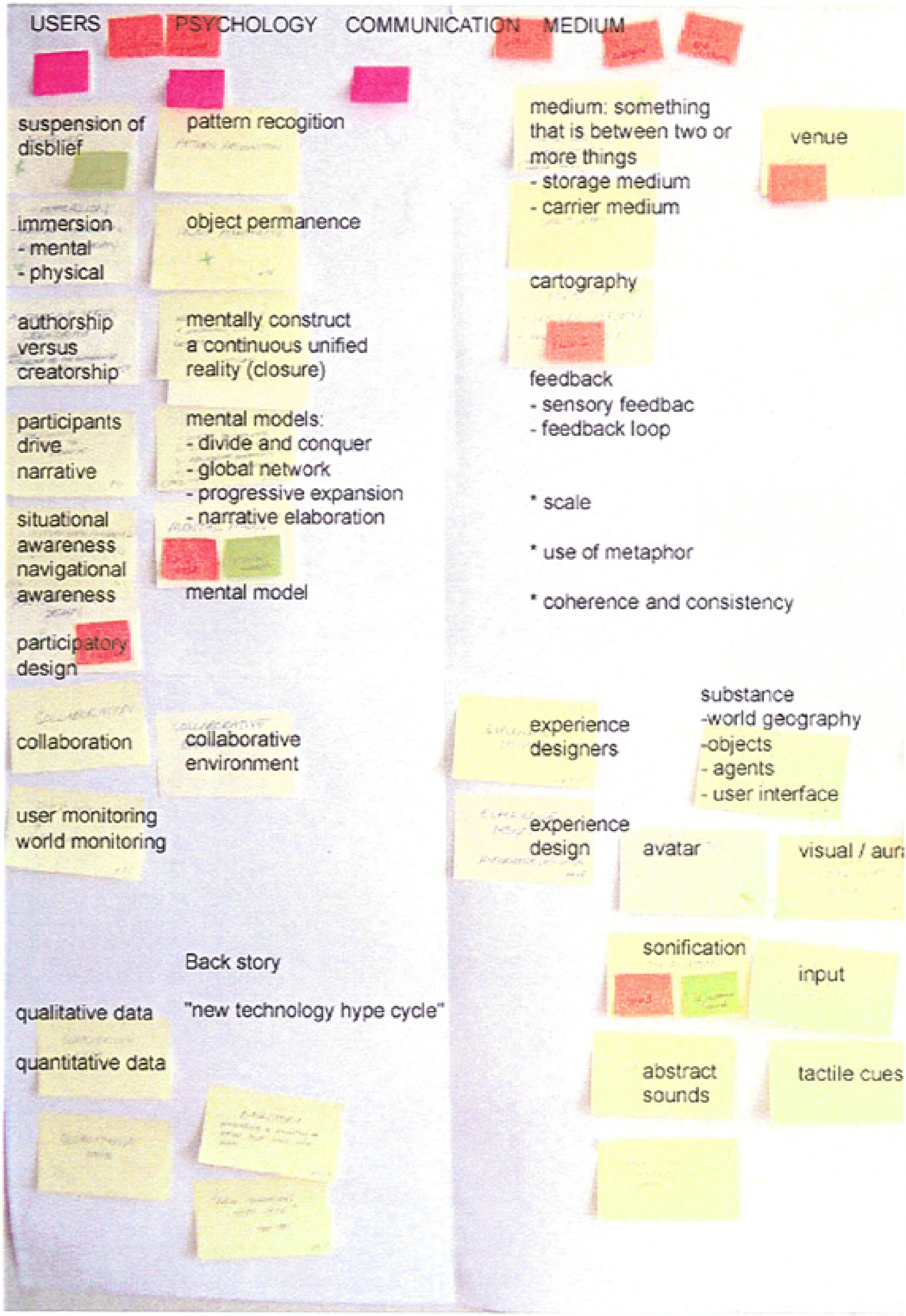


Figure VII: Q1 Mapping of Issues emerging from the Contextual Review with Text Overlay

Figure VIII: Q2 Mapping of Issues emerging from the Contextual Review with Text Overlay

Figure IX: Q3 Mapping of Issues emerging from the Contextual Review with Text Overlay

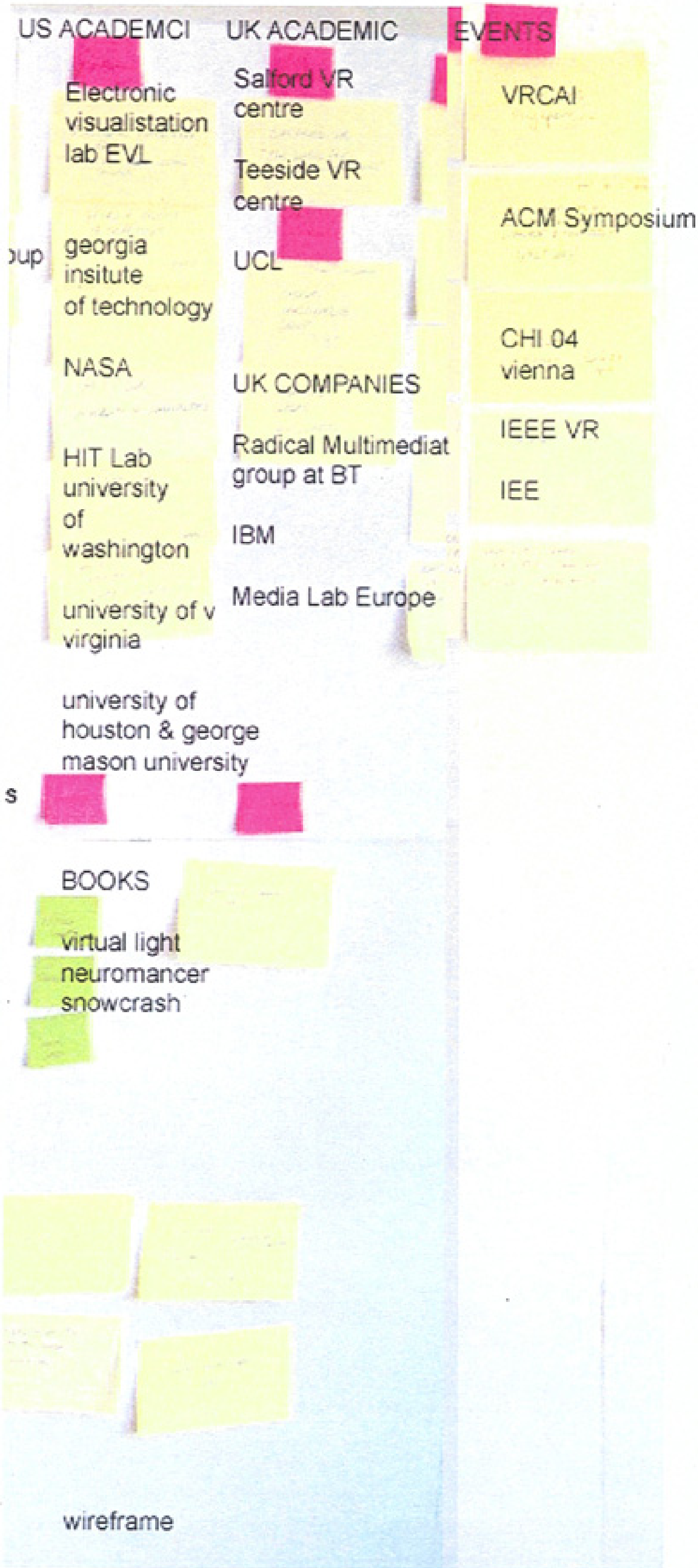


Figure X: Q4 Mapping of Issues emerging from the Contextual Review with Text Overlay

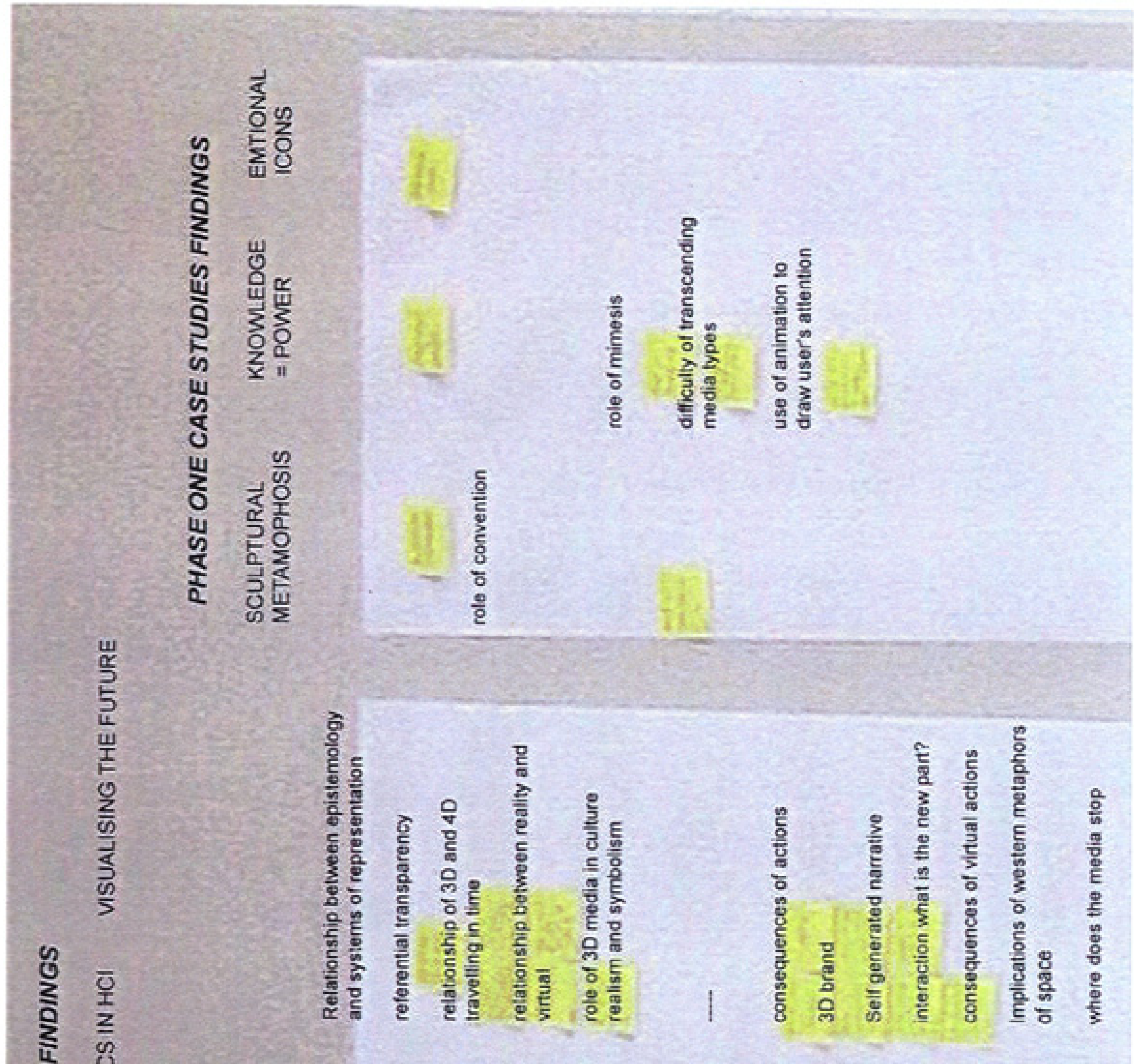


Figure XI: Section 1 Mapping of Cross Case Analysis

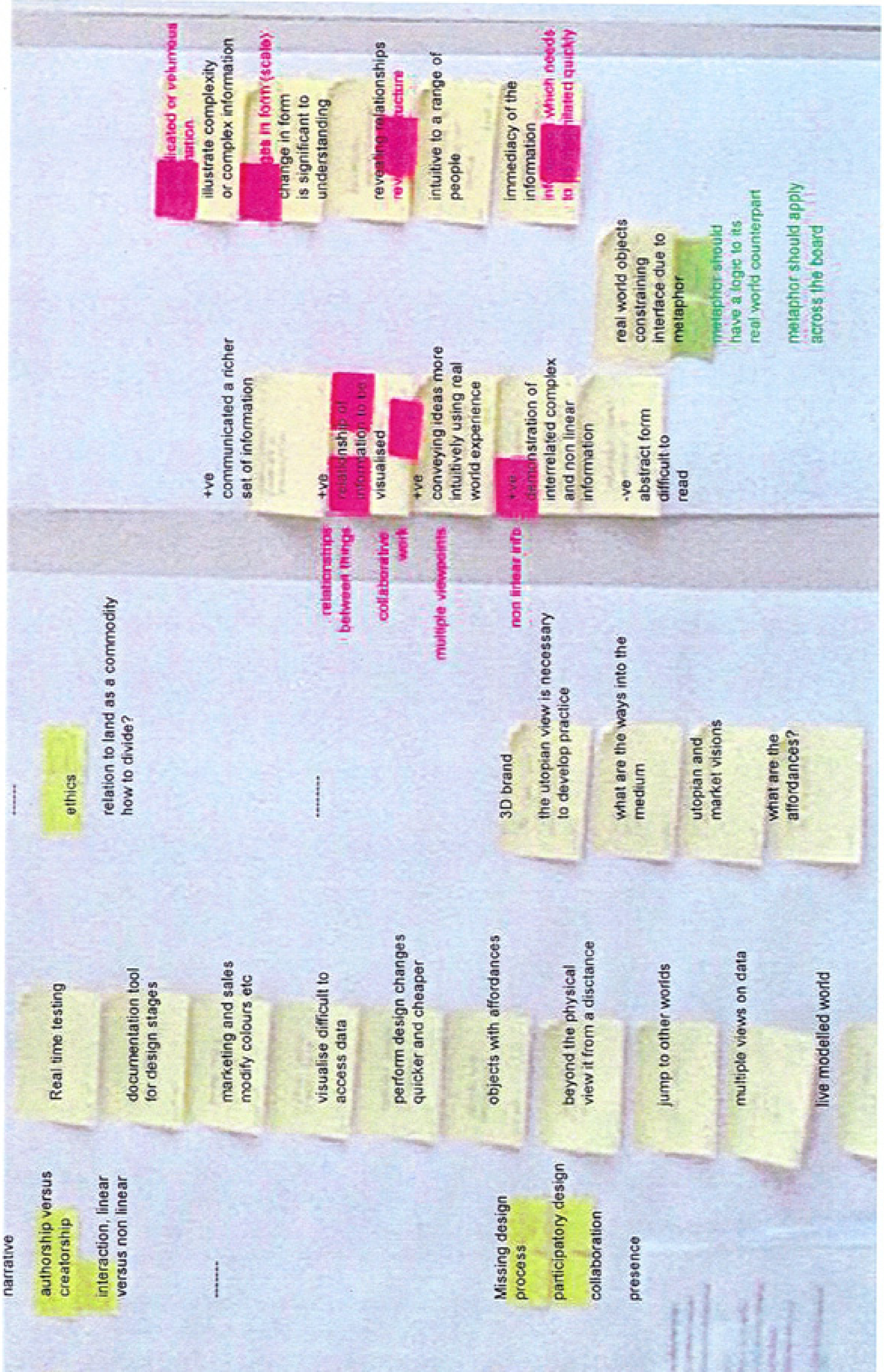


Figure XII: Section 2 Mapping of Cross Case Analysis

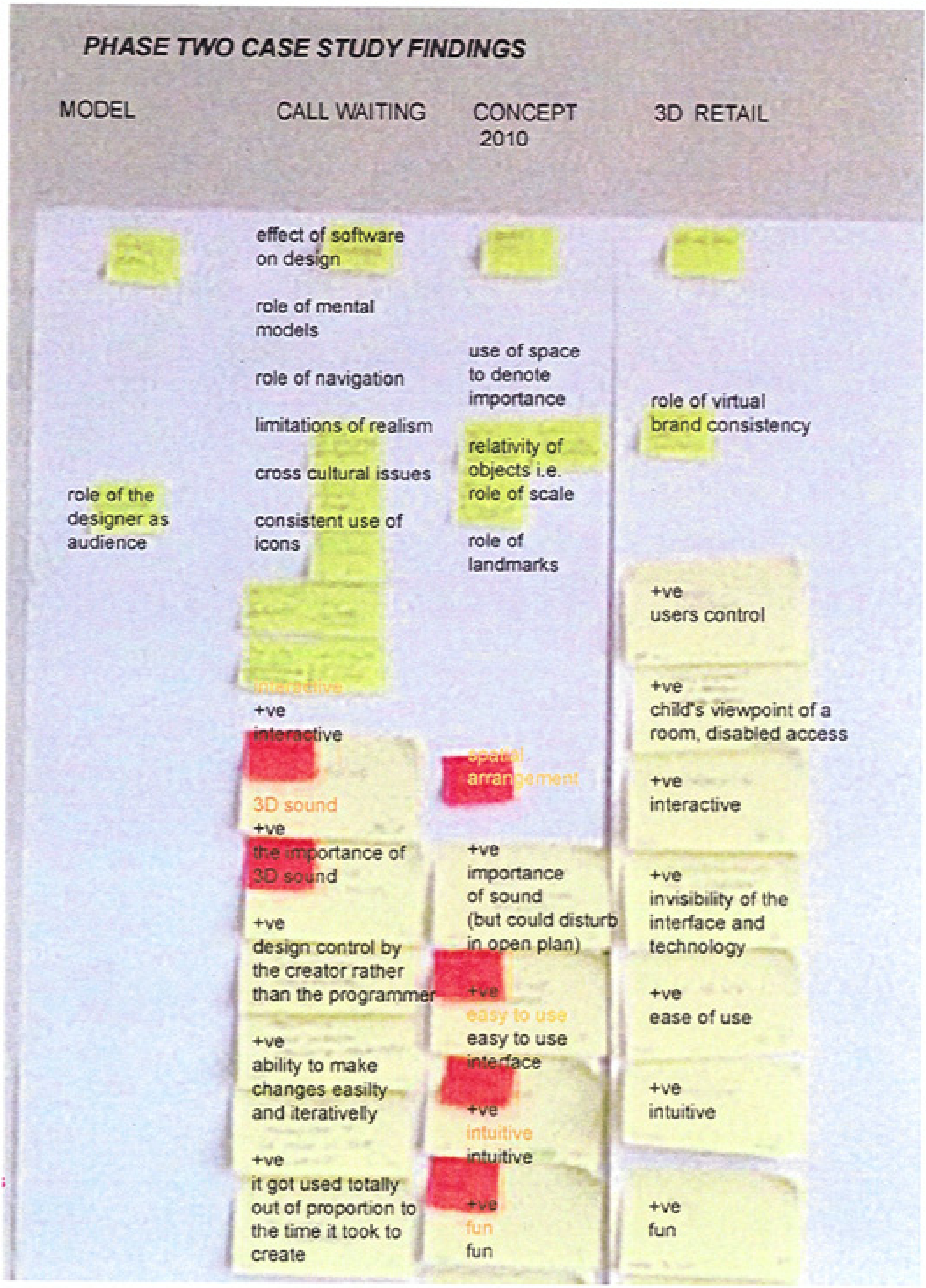


Figure XIII: Section 3 Mapping of Cross Case Analysis

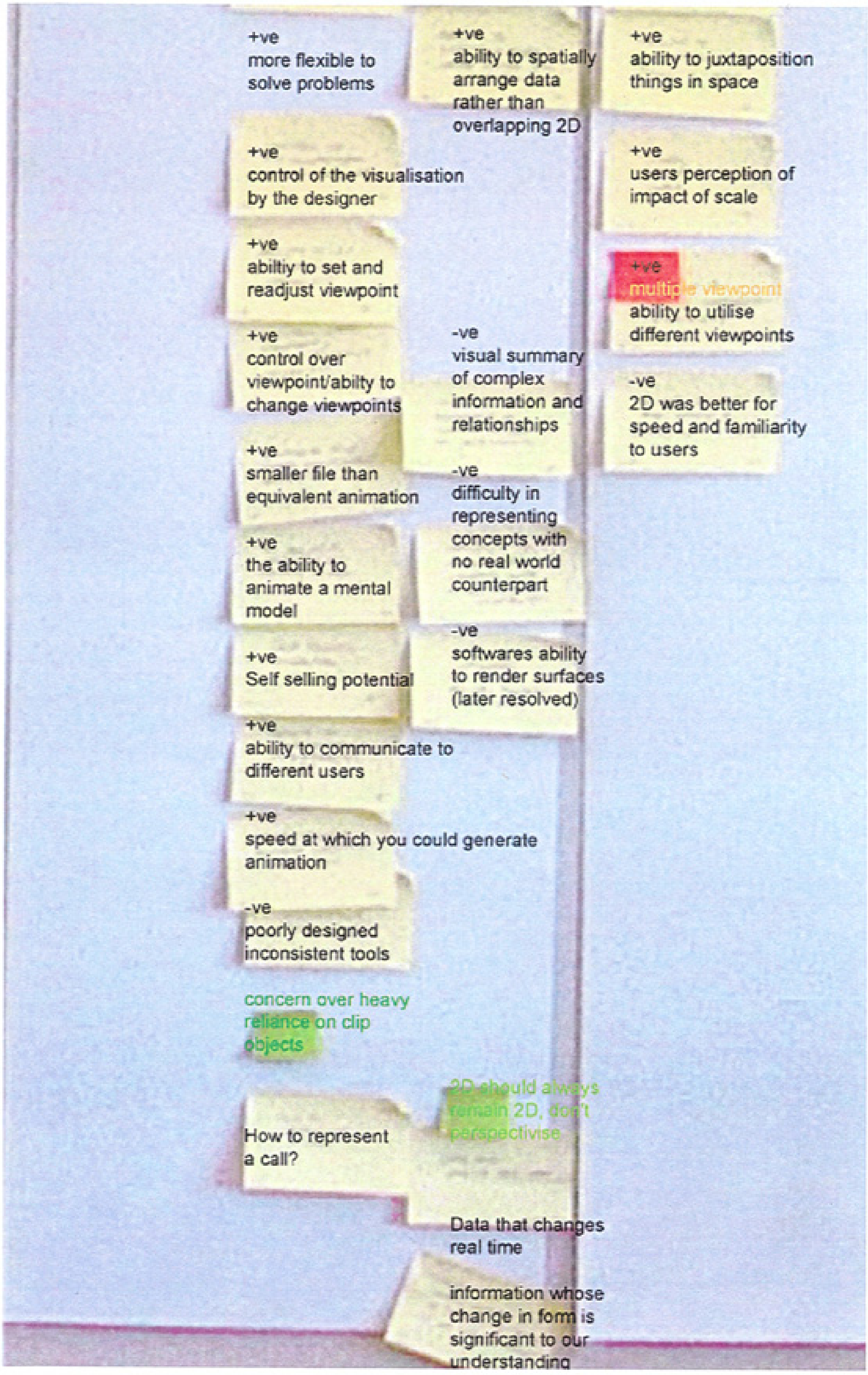


Figure XIV: Section 4 Mapping of Cross Case Analysis

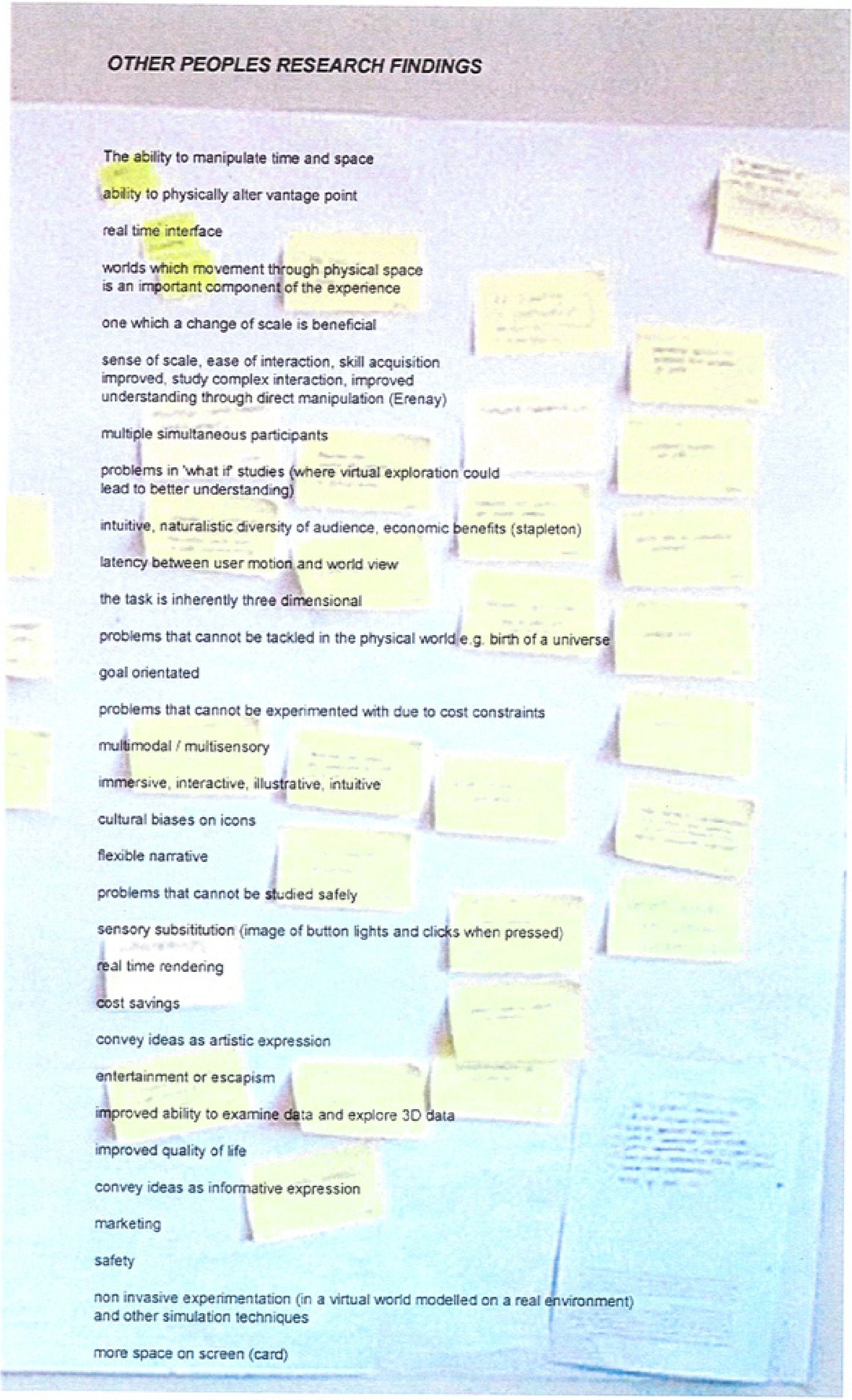


Figure XV: Section 5 Mapping of Cross Case Analysis

Cross-Case Analysis Mapping

Figure XVI: Mapping of Issues Emerging from the Case Studies

Figure XVII: Mapping of Issues Emerging from the Case Studies Close Up

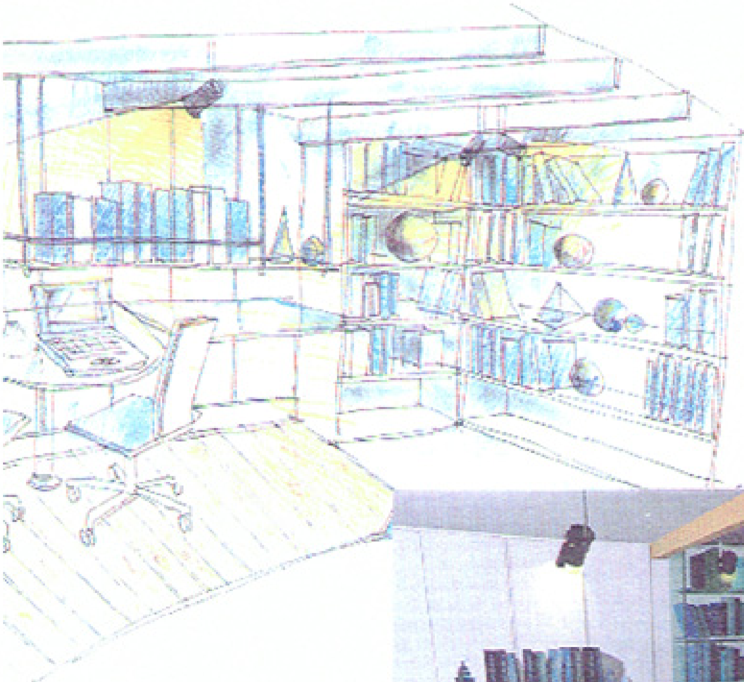
Centre for Design Research Brainstorm Images

Figure XVIII: Overview Image: Showing all Contributions

Figure XIX: Close up of Centre for Design Research Brainstorm

APPENDIX 9: DESIGN WEEK ARTICLE FEATURING THE RESEARCHER AND 'KNOWLEDGE = POWER' CASE STUDY

FIRST SIGHT CD-ROM



and a user-friendly interface using Alias software.

The CD-ROM runs only on a PC with a Windows 95 operating system – something few financial sector businesses currently have. But Siodmok says that many potential customers, such as Midland Bank, are upgrading their systems and will be able to use the disc when it is launched in two or three months' time.

Octo put together a multidisciplinary team for the job, including postgraduate student Andrea Cooper, who is studying interactive design at the University of Northumbria. Programming was carried out in Director by Tria Associates.

Design: Octo
Client: Knowledge = Power

Figure XX: Close up of Centre for Design Research Brainstorm

APPENDIX 10: PAPER FOR DIGITAL CREATIVITY

Beyond the Icon: The role of the image in Human Computer Interface (HCI) Design

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Topic Areas:
Virtual reality, Dimensionality, Representation, Metaphor

Biography

A graduate in Industrial Design, Andrea worked as a Design Consultant on consumer products, CD-ROM, Web and Interface Design. This design work has been featured in: 'Design for Success', 'Design Week', 'Revolution', 'The Telegraph' and 'Product Design' Oxford University Press. In 1995 she set up a PhD looking at advanced Graphical User Interface in Virtual Reality with BT Interaction Futures at Martlesham Heath, Ipswich. She is currently a Senior Lecturer at the University of Northumbria where she teaches on the B.A. (Hons) Design for Industry degree course as well as running the innovative course 'Contemporary Influences on Design'.

Beyond the Icon: The role of the image in Human Computer Interface (HCI) Design

KEYWORDS 3D Visualisation, Virtual reality, Representation, Metaphor

Abstract

The computer medium makes it possible to send and receive information in many different forms, using a range of signs from the iconic to the symbolic. This poses a number of problems for the interface designer who must choose the appropriate sign for the purpose being expressed. The research underpinning this paper is looking at three-dimensional images in the context of human-computer interaction (HCI) design. Much research to date within this field has been approached from an empirical or technologically determined standpoint. In contrast, this research, in collaboration with BT, is focusing on a communication centred approach. This paper will put forward an integrated model of communication which aims to categorise image and thereby create a visual taxonomy that can communicate theory to practising designers. In particular, this model will highlight both the commonality and differences that exist across different modes of representation and therefore reveal the relationship between the widely used iconic interface and the symbolic interface. The ultimate outcome of this research is to highlight design opportunities within the medium to facilitate design practice.

Introduction

If we examine communication we see the origins of some of the most fundamental systems of reconciling experience. Primarily, it is our systems of classification and categorisation that allow us to objectify the world and assign names to 'collections' of experience. Such ordering has resulted in the isolation and establishment of a basic unit of communication, the sign. However, the sign can never be the original, as communication inherently involves taking aspects of experience and converting them into a different form that merely *re-presents* the original. Pierce describes the different association of a sign to 'its object' as either an icon, index or symbol (figure XXI). An icon refers to a sign that resembles its object in some way, such as a picture of a fire. An index is related to its object by an existential connection, in the way smoke is associated with a fire and finally the word 'fire' itself is a symbol, as we have learned to understand it through convention.

FigureXXI - Icon, Index and Symbol (Adapted from FRUTIGER.A. 'Signs and symbols' 1989)

Often, the way we understand signs, whether they be iconic, indexical or symbolic, has become so familiar that we fail to see the underlying illusion (figure XXII). Of course, words are symbolic images that we have been 'educated' to decode.

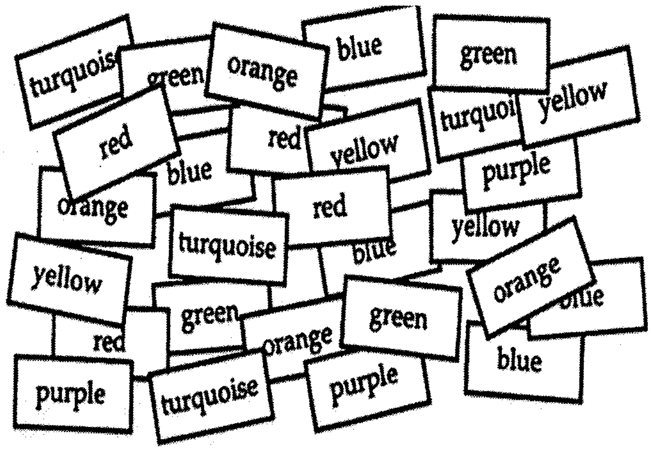


Figure XXII - The Classification of Colour "These are all one colour"

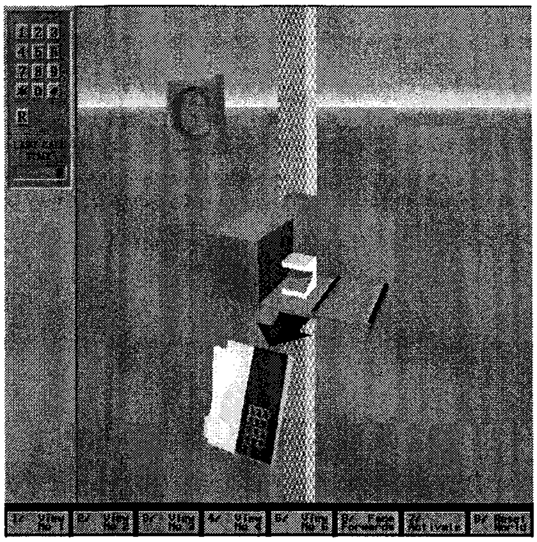
It is the interface designer who is able to order the user's experience by choosing which signs to include in an interface. In particular, where the intended understanding is at the boundary or beyond the known repertoire of signs, we often employ metaphor, to 'transpose qualities from one plane of reality to another.'[i] (see figure XXIII) However, metaphors also have the capacity to constrain concepts and classic confusion in meaning can occur, as with the apple trash can, both deleting work and retrieving your disk from the system (see figure XXIV).

Figure XXIII - Case Study Knowledge=Power, Interactive Training CD-ROM

Figure XXIV - Apple Trash Can icon

Beyond the Icon

The primary interest of this research is the identification of a space beyond iconic interfaces where designers have attempted to move away from real world referents for their virtual representations. In many instances this has been the result of 'Simulation', where scientists are attempting to model complex physical systems and simply have no real world objects to reference. These non-iconic interfaces, modelling systems using Euclidean geometry and symbolic interface, are widely thought to be opening up new areas of scientific observation.[ii] Such new knowledge is encouraged by moving beyond the Déjà vu of the real world iconic metaphor. As Michael Heim notes, "Virtual worlds evoke imagination only if they do not simply reproduce the existential features of reality but transform them beyond immediate recognition."[iii] Several examples undertaken at BT Laboratories have involved using abstract forms with emotional characteristics (Figure XXV & XXVI).



FigureXXV - Call Waiting VR Case Study, BT

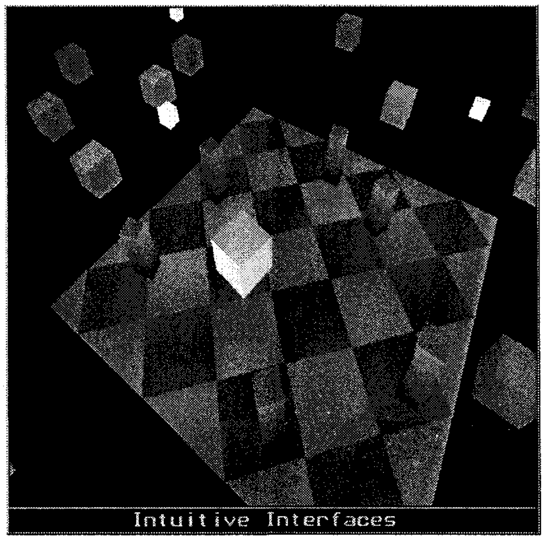


Figure XXVI - Emotional Icons VR Case Study, BT

These interfaces might be termed *symbolic metaphors* because they have metaphoric associations on at least one level, yet are embodied in a symbolic form. This is a mode of representation which designers currently seldom explore, either by technological determinism, convention or through so called 'user centred' approaches that dwell in charted territory.

The research underlying this paper is currently developing a taxonomy for identifying this segment of computer human interface (see figure XXVII). This has been achieved by mapping of the characteristics of different modes of representation, in terms of communication theory, in order to create a context for examining digital interface. To create this model, communication theories were cross-related and examined to highlight correlation and provide an integrated visual model that expresses the concepts. This has resulted in a matrix that maps dimensionality (i.e. 2D, 2D perspective, fixed path animated 3D, VR/Simulation, 3D), against the following key considerations; modes of representation (i.e. symbol, index, icon), modes of engagement (i.e. enactive, iconic, symbolic), modes of learning, interactivity and narrative (i.e. linear, user defined). The value of this taxonomy therefore, has been to make explicit the nature of the differences *within* the digital three dimensional interface, as well as positioning it contextually in relation to other modes of representation. It is considered that this will enable designers to incorporate the theories of communication studies more readily in their practice.

To conclude, this paper has laid down a framework for interface designers to explore the characteristics of the image in interface as a means of communicating knowledge through visual systems of representation. It has aimed to make alternative approaches to design content explicit within a holistic, structured concept of the medium of communication. Although it seems clear that the development of modes of representation 'beyond' the iconic require users to develop new knowledge and associations, such representations may be aligned to longer term user-centred goals, where the ultimate goal is new knowledge.

This paper highlights a starting point, a space where more research needs to be undertaken in order to make alternative methods of understanding and deciphering interface explicit. The on-going research is involved in the development of an integrated method of communicating such an understanding for evaluation by designers.

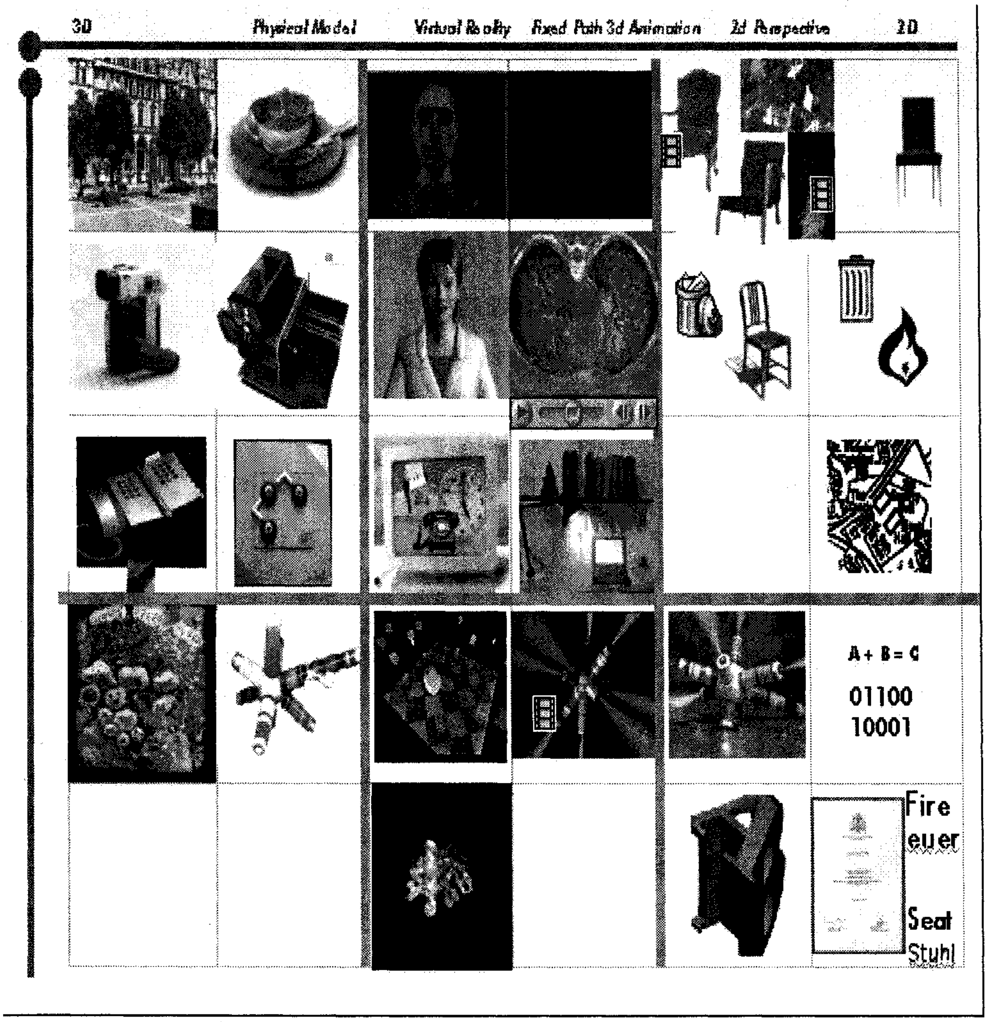


Figure XXVII - Matrix of Representation cross relating dimensionality with key Communication issues

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[i] Fiske.J. (1995) *Introduction to Communication Studies*, Second Edition, Routledge:GB
[ii] Robbins.K. (1996) *Into the Image, Culture Politics in the Field of Vision*, Routledge:GB, p.149
[iii] Heim.M. (1993), *The Metaphysics of Virtual Reality*, Oxford University Press, p.136

APPENDIX 11: PAPER FOR TMCE WUHAN CHINA

THE USE OF SOLIDS / SURFACE MODELLING AND VIRTUAL REALITY IN INDUSTRIAL DESIGN

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ABSTRACT

This paper will look at the role of surface and solid modelling techniques in contemporary industrial design practice. Using Case Studies it will highlight the key benefits and constraints of using high end visualisation packages throughout the design process including an introduction to the different design approaches used in Solid (Pro-Engineer, SDRC ideas, CATIA, Unigraphics, Solid Works etc.) and Surface modelling (Alias | Wavefront, ICEM surf, Rhino, CATIA). It will also highlight potential trends in visualisation, including the increasing use of Virtual Reality (VR) in both industrial design and transportation design practice.

KEYWORDS

Visualisation, Computer Aided Design (CAD), Alias, Pro-Engineer, Solid and Surface Modelling, Virtual Reality (VR).

1. INTRODUCTION

Computer Aided Design (CAD) started in the 2D arena with products such as AutoCAD replacing 2D manual drawing board based drafting. The rationale being that productivity would increase with features such as drafting tools and layers, along with the ability to make quick changes and communicate these directly to partners in the design and manufacture process. IBM (Dassault Systems) introduced one of the first solid modelling programs known as CATIA which took 2D drafting systems and used tools like 'extrude' and 'loft' to create simple solid models.

Surfacing technology has its history embedded in the Automotive industry. This is best illustrated with products such as ICEM surf, which originated from Volkswagon's requirements to produce 'class A' surfaces for their automotive surfacing requirements. At the same time Alias | Wavefront also evolved a surfacing tool aimed at both the Automotive, film and entertainment industries.

Since this emergence of solids and surfacing technology there has been a growth of digital tools at both ends of the design spectrum. Studio Paint is a digital sketching tool which aims to integrate the idea, or sketch phase, with the three dimensional model. Further down the design process, solid models are increasingly being used for finite element analysis (FEA); for digitally testing performance through stress conditions; mould flow and thermal modelling (figure 1).

Figure 1: Finite element analysis using Mechanica

Subsequently this information can be used for physical rapid prototypes through SLA, CNC, and FDM etc. Virtual reality (VR) is increasingly being used in the automotive industry particularly to test assembly, and human interaction with the digital model prior to committing to a physical prototype.

1.1. Process

To illustrate this paper, case studies from Alias | Wavefront, and ICEM surf will show the design process involved in various Design Consultancy projects.

The start of the design process usually involves a sketch; there are two products that aim to integrate the sketch process with surfacing and solids technology. Studio paint and Pro-designer can be used with a WACOM digital tablet to produce fluid digital sketches. The advantage of this as a pure sketch tool is similar to the initial introduction of 2D CAD, i.e. various media are integrated as tools and it allows the ability to manipulate layers and quickly make changes therefore speeding up the creative process (figure 2).

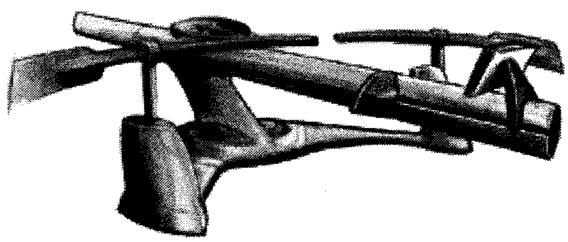

Figure 2: Studio Paint Sketch

Additionally, the ability to transpose the sketch from 2D to 3D curves and surfaces helps ensure that the design intent of the sketch is captured into the surface model. At the same time, primary (initial) surface models can be visualised in 3D and details, for example headlights, graphics or split lines, can be painted on in Studio Paint prior to extensive and more time consuming modelling. An advantage of this methodology is that a digital database is maintained throughout the design process and can be communicated digitally, for example, via the Internet. Many design consultancies and manufacturing companies elect to use tools such as Illustrator or PhotoShop at significantly lower costs, to achieve the initial illustration phase and to ensure consistency of presentation.

Often, as the sketch phase develops, there will be a technical package which impacts on the final form of the product. In both the sketch phase and the initial modelling phase, this package can be incorporated to ensure clearance tolerances and functional fits are achieved from the outset. The use of layers can be cycled through to show various iterations to focus groups, potential customers and clients.

Simple animations can be produced from surface models and used to illustrate either the assembly of the product and its component parts, or to illustrate how the product will be used in context prior to extensive engineering analysis.

1.2. Solid Modelling

The question whether surfacing or solids will be the modelling methodology for the future is a difficult one. Both methods have advantages and hurdles to overcome in the future and during this paper I will show how they can be used in combination to gain the greatest advantage from the technology available.

One of the commonest mistakes when combining surface and solid technology is not to understand the constraints of each at the outset. Surfacing technology has far less constraints in defining the topological relationship between edge boundaries. It is possible in surfacing tools such as Alias or Rhino to ignore manufacturing constraints such as tangency between surfaces, gaps and die lock, which would be flagged in a solids system. By understanding the mathematical model in the target solids system and its construction tolerances, it is possible to ensure a successful transition. Tools such as 'Surface Stitch' are used to diagnose gaps and tangency mismatch between edge boundaries and to highlight problematic areas within the model that need to be resolved before export.

Extensive Research and Development effort has gone into cross platform export languages such as DXF (Drawing Exchange File) and IGES (Initial Graphics Exchange Specification). The latest translators use 'flavoured' IGES (IGES which understands construction and mathematical constraints of target systems) or STEP and direct translation, which has been tested extensively on both platforms. Whilst collaboration between competing CAD companies is helpful for product designers and engineers, it does not always happen in the commercial world.

Once the surface model has been successfully imported into the solid system it can be used as the external or A surface framework to produce the offset B surfaces (internal surfaces), structural engineering elements and the inner of the casework. The advantage of the solid modelling system to perform this is the speed of offsetting surfaces and evaluating these in real-time on the screen. Typically a solids system will produce lighter, less complex offset surfaces and will handle intersecting ribs and bosses in a much more usable manner due to the way solid models handle Boolean operations. The ideal relationship between the A surface and the B surface is for there to be associatively between the two. If this is the case then if there is a change to the A surface and the B surface will automatically update in order to reflect the A surface change with any intersecting elements, such as ribs and bosses, automatically being re-intersected with the new offset B surface.

1.3. Direct Modelling

Another approach often taken is Direct Modelling. This is used in Reverse Engineering. Following the sketch stage some designers will elect to enter a physical model making stage rather than a digital one. Clay is often used by automotive and product designers to sculpt complex forms. This allows the designer to get feedback from focus group 'clinics' and to evaluate early design direction. Clearly, using this method the link in the digital design database is broken, and the challenge is to capture the design intent in the physical model and transfer this back into the computer so that engineering elements and rapid prototyping advantages can be gained through 3D CAD.

Contact or non-contact (laser) digitisers are used to capture either strong feature lines or cloud point data from the clay or physical model. This information is then imported into Alias or ICEM surf for visualisation to ensure that the information has been transferred correctly. This data can then be used as a foundation for surfacing using the ICEM surf or Alias product. In direct modelling surfaces can be snapped onto the cloud point data and diagnostic tools used to evaluate the deviation between the cloud and the A surface. This process enables the designer to slowly build an accurate clean surface model from the digitised clay design model. This data then can be interrogated in terms of technical package, hard points and edge boundary relationships and subsequently used for engineering tooling.

1.4. NURBS versus Bezeir Maths

NURBS (Non-Uniform Rational B-Spline) maths is used to describe complex or multi-span surfacing. The advantage with this approach is that curves can be quickly sketched over cloud point data or imported sketch images, to quickly build up a surface model. The disadvantages with NURBS maths are both the data size created by complex surfaces and the difficulty in controlling tangency and curvature between the boundaries of complex NURBS surfaces. As the edge boundary relationship becomes more important and the quality of surfaces increases then often designers look towards using Bezeir or single span surfacing techniques. This can be achieved by either using high order curves with careful analysis of the curvature map to produce single-span surfaces or by using direct single-span modelling techniques.

The decision of whether to use Bezeir or NURBS math approach (single span versus multi-span) more meticulous surfacing approach depends on the quality of the end surface in production.

1.5. Surface Evaluation

Zebra stripping can be used as real time reflection mapping tool to evaluate surface quality, continuity of curvature and highlight lines. Specific products like evalviewer aim to speed up the process by linking to SGI hardware texturing giving interactive feedback as the model is tumbled – even stripping represents good surface continuity.

2. VIRTUAL REALITY (VR)

2.1. Background to VR

The historical development of communication has caused huge changes in society, with new developments in media being proclaimed by Robbins (1996) as the arrival of a new visual language. This language has been expressed through the development of computer based virtual reality, multimedia and internet capabilities, which are capable of use as a medium for communicating design concepts using digital imagery. This part of the paper looks at what systems are currently being employed by designers to represent products using virtual reality and looks at the benefits of these systems for the design process.

The computer medium makes it possible to send and receive information in many different forms, using a range of methods from e-mail to Virtual Reality. This poses a number of problems for the industrial designer who must choose the appropriate method for the purpose being expressed. The research underpinning this paper is looking at three-dimensional images in the context of human-computer interaction (HCI) design. It is concerned with the way such imagery can be used to communicate an intended design from the standpoint and benefit of the designer.

The first stage in the recent image revolution has resulted from the progression from photographic media to digitally enhanced images. This change in image has been described by Philippe Queau as 'comparable with the appearance of the alphabet, the birth of painting or the invention of photography...a new tool of creation and also of knowledge.'(Robins, 1996). However, the way the medium is employed depends upon our chosen approach to the design of its form, and thus, its capabilities. As noted by Forester (1996): "As we build electronic networks and begin to interact regularly with all parts of the planet, we must pay serious attention to the form and content of communication, since it will develop into a global language that will become our common possession..."

2.2. Virtual Reality Technologies

There are a number of types of Virtual Reality technologies and techniques available to the designer including: Augmented Reality; Mixed Reality, Desktop VR and Fully Immersive VR (all systems can be used with or without haptic controls). How the designer utilizes these technologies varies; each having their own benefits and constraints, and in particular their own associated costs.

Fully Immersive VR Systems

This is traditionally considered the only type of VR as epitomized in film and television, in movies such as Lawnmover man, it refers to VR systems with headsets providing a near compete sensory replacement reality.

Desktop VR

Increasingly designers are looking to Desktop VR to widen participation and reduce cost and complexity for users. Superscape's VISCAPE is capable of delivering relatively sophisticated graphics running on low specification PCs. Similarly, VRML has been used to display three-dimensional data over the internet.

Augmented reality

Augmented Reality, sometimes referred to as Mixed reality, refers to the overlaying of digital information onto real world images or contexts. Augmented reality is often used with CAVEs to allow users to be put in physical environments with VR information. Similarly, sound can be used to augment reality, as with navigation systems designed to assist the blind via radio signals.

2.3. Key Applications of Virtual Reality

Key applications of VR include: Simulation (Scientific visualization, Architectural visualization, complex process mapping); Design Development (form fit functionality, user-centred interaction design, animation); Entertainment (games); Training (medical training, flight simulation) and Collaborative environments (Tele-medicine, Virtual Conferencing, MUDs (Multi User Domains), MOOs (Multiuser domains Object Orientated), CSCWs (Computer Supported Collaborative Work).

This paper will look in particular at the opportunities available to the designer in Design development.

2.4. Design Development-

Form-Fit Functionality

Whereas CATIA can provide tangible form-fit data on parts within a design, such as engineering clashes or mould flow constraints, VR extends this capability to the context the product will ultimately occupy. For example, a room can be modelled by the designer, into which virtual furnishings can be arranged and tested. Additional anthropometric 'form fit' data can be included in the model leading to a greater awareness of user interaction.

User-Centred Interaction Design

Virtual Reality's ability to allow the anthropometrics of the individual to be reproduced into the environment provides the designer with a tangible insight into the perception of the ultimate user of their product.

Here a designer can see the world from a child's viewpoint as well as an adult at the click of a button. This provides clear ergonomic data for the design team.

Additionally, task modelling can be used to isolate and identify problems in usability (Figure 3).

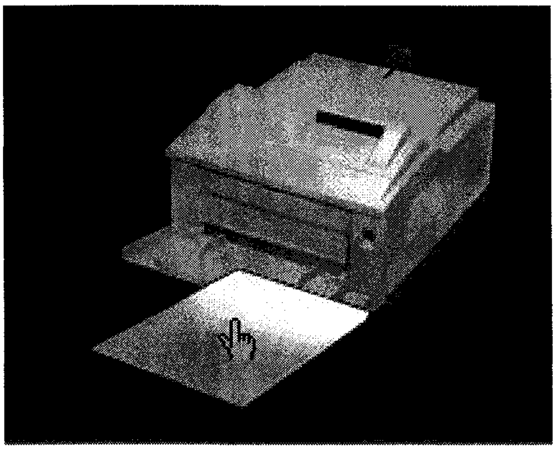

Figure 3. Usability testing using Quick-time VR

Likewise, early trials with real users can be undertaken using simulated environments and products providing valuable, low cost, feedback to the design development team. For example the designer can use virtual reality to apply controls to a car's binacle or an interface onto a product and test the integrated functionality of the screen and physical product in use.

Animation

The use of animation in design is now widespread. The key difference between traditional animations and VR animation is that the user has control over the views of the product. An innovative group in Berlin, Art+Com used VR to model the Daimler Chrysler A-class.

2.5. Issues for the Designer

Key issues faced by a designer using VR include choice of metaphor, level of narrative or control (linearity within the system) and navigability. How the designer responds to these issues depends largely on the ultimate users of the system, i.e. whether they are expert or novice with VR technologies.

Metaphor in Visualisation

All virtual worlds use metaphor in one form or another to communicate concepts to users. This allows users to consider the information presented in terms they understand, as Fiske (1995) notes: to 'transpose qualities from one plane of reality to another.' Such organisational representations, metaphors, or 'mental models', make sense of the Virtual World for users. This association between the real world and representation is clearly evident in VR, where the notion of Mimesis, Laurel (1993), has been ascribed to the heavily reflective nature of the interface appearance. Athavankar (1989), suggests: "It is significant that the decision on this [object's] positioning is primarily on the basis of the visual information associated with concrete objects." This can provide additional insight into why 'real' world representations are so prolific in the HCI environment, as they are clearly seen 'most often'. Thus, daily experience provides the user valuable feedback and confirmation of the system (Figure 4).

Figure 4. Knowledge = Power Case Study

Narrative

Narrative is usually associated with more traditional media (books, television etc.), however in VR, the level of narrative is an important consideration if the user is to understand how to use the space effectively.

Sherman (1993), suggests that the essence of virtual reality lies in what he describes as the five 'i's: intensive, interactive, immersive, illustrative and intuitive. As he notes: "It is the user's inclusion in this illusionary world, and the ability to influence what happens in it, that makes all the difference between virtual reality and ordinary computing, the movies, television or art." Without set paths or navigational cues users can quickly become confused in VR worlds.

Navigation

As noted above one key characteristic of Virtual Reality worlds is the capability for the user to have significant control over their environment. In this way they can choose non-linear paths through the information displayed to them.

Flying carpets and virtual CAIRNS (A trail of virtual pebbles) are just some of the methods being employed to allow users to track progress through a virtual space. However, increasingly users are highlighting the 'reset the world' function as the most important tool for navigation.

2.6. Benefits of using VR in the design process

VR has yet to be used widely in the design process beyond large companies such as BMW and Daimler Chrysler or transnational corporations - Microsoft, IBM, Exxon, Mitsubishi, AT&T, Philips, BT and so on - whose primary interest in developing new technologies are commercially determined.

However, the early examples of using VR show benefits for the design process including:

- Reduced cost,
- Significant error reduction,
- Iterative design development prior to tooling,
- Customer surveys, trials and marketing – in some cases leading to direct VR sales.

Additionally, with the use of the internet for example, designers can communicate their work internationally, transcending both geographical location as well as time boundaries. The juxtaposition of images, text and animation appears seamlessly on the screen and can be used to communicate design ideas to clients. In this way many design consultancies are already using 'client rooms' to present concepts to clients as the design concepts progress in real time.

Virtual Reality over the internet can be seen as yet another tool for the designer to communicate concepts within the design process. Systems such as VRML, Superscape and DVISE can be used to complement existing CAD packages and add new functionality and design knowledge within the process.

2.7. Design Futures

Although VR systems in place today are quite crude in visual terms, this will be superceded by high impact images as the growth of computer power and size reduction occurs, as predicted by Moore's Law (Gates, 1996). Any early technical flaws, such as poor polygonisation, will be eliminated by increased computer power in due course.

2.8. Integration of Visualisation and VR

Within the design process the integration of systems such as Alias and CATIA and DVISE is an issue to be considered. Data translators such as IGES and STEP are being superceded by specific software code, which enables direct transfer between target CAD systems. Within the global automotive industry systems, such as DVISE, can be used as a visual database for project management and evaluation purposes.

CONCLUSION

The development of advanced computing and software capabilities has transformed the working practices of the designer. Understanding such complexity and integrating systems coherently has been an important element in reducing lead times, whilst simultaneously maintaining design integrity. The Integrated use of solids, surface and VR technologies can deliver real benefits to clients, reducing errors, cost and providing a permanent data trail for future reference.

Virtual Reality is currently being used in simulation, training, entertainment and collaborative working environments. In design it has been used for form-fit functionality, user centred design and animation. However, with the combination of high costs and limited availability of specialist software designers, VR has yet to become ubiquitous in Industrial Design. For large companies, such as Daimler Chrysler, it has proved to be a powerful tool in improving design quality; being used to simulate a broad range of anthropometric data as well as constructing hypothetical scenarios and contexts. This in turn has led to a reduction in errors and has shown cost benefits. In smaller design consultancies the financial benefits of investing in VR are still to be proven, however, examples of its effective use can be found, including the work of Art+Com and aka Visualisation Ltd.

For designers, coming to terms with such software can be demanding and certainly requires flexibility and perseverance. However, with the development of more advanced hardware such as haptic input devices and desktop 3D solid printing, the gap between traditional design skills and digital development is ever decreasing.

Some have hypothesized the emergence of the digital, paperless office. In design, there has been a significant move towards an entirely digital design process. In such an environment, digital design tools are fundamental. However, as well as presenting significant opportunities they can also present obstacles, such as 'unexpected' delays in data transfer or even complete data loss. Foresight in planning the integration and transfer of data across systems, along with the proper safeguards on data backup are two critical elements that can ensure low risk, high quality design. Likewise, investment in training and software/hardware is essential.

If these risks are managed the potential of digital design development integrating solids/surface and VR is significant in developing safer, more usable, predictable and cost effective design.

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APPENDIX 12: PAPER FOR EUROMICRO

Beyond the Icon: The role of the image in Human Computer Interface (HCI) Design

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Topic Areas:
Virtual reality, Mimetic interface, Dimensionality, Representation, Metaphor

Neither this paper of any version close to it has been or is being offered elsewhere for publication. All necessary clearances have been obtained for the publication of this paper. If accepted, the paper will be made available in a camera-ready forms by June 15th, 2000, and it will be personally presented at the EUROMICRO 2000 Conference by the author or one of the co-authors. The presenting authors will pre-register for EUROMICRO 2000 before the date of the Camera-ready paper."

Beyond the Icon: The role of the image in Human Computer Interface (HCI) Design

Abstract

The historical development of communication has caused huge changes in the way we perceive the world. Developments in media have gone as far as being proclaimed by Robbins[1] as the arrival of a new visual language. This language has been expressed through the development of computer based virtual reality, multimedia and internet capabilities, which are technologically capable of use as a medium for communicating ideas using images. To date this computer environment has predominantly employed a two-dimensional system of representation using a metaphor relating to traditional office work activities. However, as technology improves, the question remains how interfaces might best use three-dimensionality to present information to the user? This paper considers the relevance of theories of communication studies, psychology and semiotics[2], as a means of 'de-mystifying' our understanding of image in interface design. It maps different forms of communication media in order to create a context for examining future interfaces. Therefore, it asks what visual attributes are appropriate for the three-dimensional interface and if there is value in moving beyond the convention of a mimetic interface?

Background

The computer medium makes it possible to send and receive information in many different forms, using a range of signs from the iconic to the abstract and symbolic. This poses a number of problems for the interface designer who must choose the appropriate mode for the purpose being expressed. The research underpinning this paper is looking at three-dimensional images in the context of human-computer interaction (HCI) design. It is concerned with the way such imagery can be used to communicate an intended meaning, principally from the standpoint and benefit of the interface designer. Research completed to date within this field has been approached from an empirical or technologically determined standpoint. In contrast, this research, in collaboration with British Telecommunications PLC Research at Ipswich, UK, is focusing on a communication centred approach. This, it is hoped, will provide a strategic framework from which the medium can be considered. The ultimate outcome of this research is to highlight design opportunities within the medium to facilitate design practice. This paper discusses the basis of theories of communication in order to clarify the designer's role of image in HCI design.

Introduction

The first stage in the recent image revolution has resulted from the progression from photographic media to digitally enhanced images.[3] This change in image has been described by Philippe Queau as 'comparable with the appearance of the alphabet, the birth of painting or the invention of photography...a new tool of creation and also of knowledge.'[4] However, the way the medium will develop depends very much upon our chosen approach to the design of its form, and thus, its capabilities.

> *As we build electronic networks and begin to interact regularly with all parts of the planet, we must pay serious attention to the form and content of communication, since it will develop into a global language that will become our common possession...*[5]

The idea of global communication, is something that has become increasingly familiar in recent years. When we search the internet for example, one might easily believe that the whole network is written in one language, however, of course it is not - we have simply developed a means of filtering out the languages which are not appropriate. Not only, of course in terms of traditional geographical language differences, but also in terms of the visual, where the filtering mechanism is more subtle. The juxtaposition of images, text and animation appears seamlessly on the screen and yet communicates very differently. In our daily interactions we are often unaware of the power the medium has upon the message we are receiving, as Marshall M^c^Luhan noted, "The medium is the massage". For decades, linguists have attempted to resolve differences in verbal and written language, but the use of digital imagery, especially three dimensional imagery, as a means of communicating experience has only recently become technologically feasible and is therefore a new subject for the communication designer's debate.

As we examine communication we see the origins of some of the most fundamental systems of reconciling experience. Primarily, it is our systems of classification and categorisation that allow us to objectify the world and assign names to 'collections' of experience. In this way we learn to divide the world into night and day, myself and others, chairs and tables and so forth. In 'Categorisation Natural Language and Design', Athavankar[6], looks at this process of mental categorisation in language and products confirming that although;

> *...the human brain offers a seemingly unlimited capacity to store symbols for objects and events of the environment...the need for effective retrieval from this vast storehouse of information has prompted humans to develop a storage strategy based on semantic coding and organisation of input information.*

Thus, the world is grouped into systems, divided binary oppositions and structured into hierarchies of meaning. This mechanism takes the world as an unrecognisable mass and breaks it down to enable concepts to be considered. The ordering of the environment by individual societies allows for the chaos caused by the unknown or inconceivable, to be reduced. Such ordering has resulted in the isolation and establishment of a basic unit of communication, the sign.

However, the sign can never be the original, as Fred Forest suggests; "...the observer can always notice the presence of certain elements (physical) or signs (visible or audible) which by a process of mental projection, lead him to reconstitute the overall representation."[7] Communication inherently involves taking aspects of experience and converting them into a different form that merely *re-presents* the original. The observer is then the receiver of the message, as Anne Tyler notes: "The goal of all communication is "to induce in the audience some belief about the past..., the present..., or the future."[8] The idea of 'some belief', not necessarily what was intended, allows for discrepancies in the message between individuals. However, it also highlights one of the fundamental distinctions in communication studies, one of approach. There are two main approaches, the semiotic approach and the process method. Fiske suggests the following distinction; the 'process' school is said to see communication as the transmission of messages, whereas semiotics sees communication as the production and exchange of meanings.[9] It is the second school, semiotics, which this paper focuses on and its attention to the text: "In semiotics the status of the receiver, or reader, is seen as playing a more active role."[10] This approach has been created from the work of Charles S. Peirce, and Ferdinand de Saussure. Peirce, describes the relation between the sign, the object it represents, and what we interpret that to mean as follows:

> *A sign is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. The sign which it creates I call the interpretant of the first sign. The sign stands for something, its object.*[11]

In order to derive understanding from the world we translate such signs into personal meanings. Although we might consider the world to comprise actualities, or facts, how we read these facts depends on our systems of signs (our interpretant), thus a rose can represent a kind of flower, or a political party, depending on the associated signs in its context. What this highlights is that the same image can create different meanings and thus the same meaning can be explained by many different images. Pierce describes the different association of a sign to 'its object' as either an icon, index or symbol (figure 1). An icon refers to a sign that resembles its object in some way, such as a picture of a fire. An index is related to its object by an existential connection, in the way smoke is associated with a fire and finally the word 'fire' itself is a symbol, as we have learned to understand it through convention.

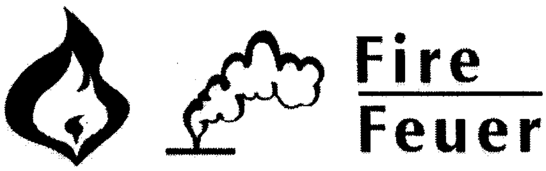

Figure 1 - Icon, Index and Symbol (Adapted from FRUTIGER.A. 'Signs and symbols' 1989)

As Adrian Frutiger notes: "Understanding what a thing *represents* - as opposed to merely what it *depicts* - is a prerequisite for using the sign correctly, since the same physical representation can be used in many signs."[12] Here, reading a flower as an analogue for a political party would be interpreting the meaning incorrectly. Often, the way we understand signs, whether they be iconic, indexical or symbolic, has become so familiar that we fail to see the underlying illusion (figure 2). Of course, words are symbolic images that we have been 'educated' to decode. The painter Magritte, plays with such concepts of sign, highlighting the power struggles between different media and interestingly, revealing the dominance of the image (figure 3).

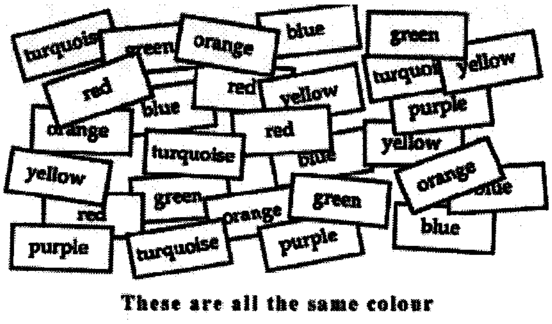

Figure 2 - The Classification of Colour

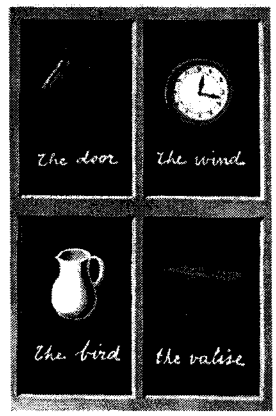

Figure 3 - Magritte (From GABLIK.S. (1992) Magritte Thames and Hudson)

Frutiger notes the impact of images on the HCI environment:

> *Few would argue that images are not among the most important elements in a visual computing environment. Their impact on the presentation of a conceptual model, the tightness of the feedback loop between person and machine and the apparent tangibility of a synthetic virtual space is greater than any other aspect of the application.*[13]

Signs, (e.g. words, pictures or numbers) are used to support the graphical user interface because they convey meanings and because binary computer machine code is difficult to decipher. However, with images the association between the sign and the signified can be so strong the illusion appears seamless. Such instances of 'perceptual coherence' account for a matching of basic hierarchies of semantic coding by the user to the experience that is being processed of the world. Thus, if we consider concepts of good design in HCI, they represent a match of expectation to deliverable. In this case it is not surprising that the U.S. trash can confused British users, who thought it looked more like a post box than a waste bin (figure 4), and that "Sun Microsystems found that the icon chosen for their Sun View electronic mail product was problematic. This image is even confusing to some American urban dwellers who are unfamiliar with rural mail boxes."[14] (figure 5)

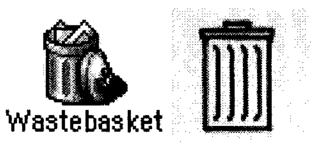

Figure 4 - Apple Trash Can icon. Figure 5 - SunMicrosystems mail icon.

With the application of this ever increasing 'structure' within cultures, individuals are often under the false impression of thinking that *their* perception of events (personal construct or lexicon) is representative of the world at large. "Paradigms are powerful because they create the lens through which we see the world."[15] However, it is the interface designer who is in a key position to order the user's experience, by converting raw perceptual data into culturally coherent interfaces. The power of this ordering, although often inconspicuous, is considerable. As exemplified in Chikszentmihalyi's observation that:

> *Basic patterns such as straight lines and right angles are easily isolated and recognised by people living in a 'carpentered world' those used to a more organic environment fail to perceive such units as separate from the rest of the perceptual context.*[16]

Such shared representations give different individuals within a shared culture a sense of order. Subsequently, from the most basic sensory interactions it can been seen that we make structures and concepts which enable us to reach higher conceptual levels and thereby facilitate unambiguous communication. However, in many cases it seems logical that such categorisation, as well as aiding us, confines us to understanding the future in terms of past experience.

Where the intended understanding is at the boundary or beyond the known repertoire of signs, we often employ metaphor, to 'transpose qualities from one plane of reality to another.'[17] Thus, it is often the case that the kind of organisational representations, metaphors, or 'mental models', we use to make sense of our perception also reveal the deep underpinning systems of choices upon which they are based. An example here might be the use of monetary representations for time, as in 'wasting' time and 'running out of' time, when of course time does not actually posses such attributes. These metaphors have been used in the language of our western society for so long that they are accepted as truisms, assumptions that we make every day. However, metaphors do have the capacity to constrain concepts and classic confusion in meaning can occur, as with the apple trash can, both deleting work and retrieving your disk from the system (figure 4).

The conceptual structures employed to resolve our environment may reduce anxieties associated with chaos when we approach new information in terms which we recognise, however, it also seems to pose some fundamental problems for communication between individuals as well as communication between individuals and machines. What this results in might be a form of exclusivity, a so-called 'semiotic elite', that only members from the same group can understand the specificity of the metaphor or sign. In fact many philosophers, including Kant, suggest this is the only system we have, "...philosophy has moved gradually from the unique reality of a single fixed world to a diversity of worlds."[18] However, where the systems of signs must be shared, a universal approach is required, based on culturally shared values.

> *The relativity of esthetic values does not mean that there cannot be 'good' design. Good design is a visual statement that maximises the life goals of the people in a given culture that draws on a shared symbolic expression for the ordering of such goals. If the system of symbols is relatively universal, then the design will also be judged good across time and cultures.*[19]

Communication systems must overcome any major differences across cultures if there is to be an unambiguous message, whether this is by actual resolution or, as is more often the case, by illusion. Yet this does not mean that the past singularly determines the future, rather it provides a means to identify, judge and understand new experiences. Athavankar suggests that in addition to seeking order, we also actively seek change: "The human mind works to balance two contradicting requirements. It seeks deviations that interest but also simultaneously searches for belongingness."[20] This is also noted by Crozier. In a discussion on familiarity, he cites Berlyne's prediction; "that people will most like objects and places that are moderately familiar and will be more averse to the novel and the over-familiar."[21] Too much change can challenge our existing constructs of thought, causing us to rely more heavily on the predictable unchanging aspects of our world to support new experiences. In the early introduction of the computer much was new and novel which might indicate why the more familiar iconic environment was such an early success. Yet this novelty was short lived as Mark Weiser of Xerox PARC notes; "Disappearance is a fundamental consequence not of technology but of human psychology. Whenever people learn something sufficiently well, they cease to be aware of it." So how can our understanding of communication and representation be used to create new interface opportunities?

Beyond the Mimetic Interface

The 'enactive' as expressed by psychologists such as Bruner (1966) and Piaget (1954) is the foundational learning mode. It describes a base level of learning where "Our understanding of the world is fundamentally linked to visual stimulation and the tactile experience of manipulating objects in our environment." [22] Such an approach to HCI is not new, it formed some of the key thinking in the early Xerox PARC interface developments by Norman Cox. Such a rationale suggests that when we experience a new concept, for example the introduction of a new graphic to an interface, it is measured in relation to concrete 'enactive' experiences. Athavankar suggests: "It is significant that the decision on this [object's] positioning is primarily on the basis of the visual information associated with concrete objects."[23] This association between the real world and representation is clearly evident in Human Computer Interface design, where the notion of Mimesis[24] has been ascribed to the heavily reflective nature of the interface appearance. It is not surprising then that the obvious concrete metaphor for 'work' and therefore, the computer interface, relates to the old style of work environment, using files and desktops, telephones and printers. This now familiar 'desktop metaphor', presents new information in terms of how it relates to the old familiar information.[25] Again it would seem we are seeing the power of the past in determining the potential of the future. However, this can be problematic because the power of a term, once accepted by a culture affects how that object is perceived by the culture. Thus, in emancipating us from tickertape style DOS the 'desktop metaphor' paradoxically also constrains us by presenting many of the *problems* of the old workspace in the new interface. This makes it difficult to improve beyond the boundaries of the metaphor. This has been seen time and again with products and interfaces, the classic example being the introduction of the QWERTY keyboard, designed in the 1890s to slow down the speed of typing (due to mechanical problems with keys sticking). However, this interface has become so conventional, that even given the technical competence to improve the efficiency of the system its power as a concept has ensured its survival today. This highlights the next point and potential concern, in our creation of systems of categories, which is that the 'typical' is considered to be based mainly on numerical strength rather than concepts of good or bad.[26] It would seem that the system that is most powerful in setting the paradigm, is the one we see most often. This can provide additional insight into why 'real' world representations are so prolific in the HCI environment, as they are clearly seen 'most often'. Thus, daily experience provides the user valuable feedback and confirmation of the system (figure 6).

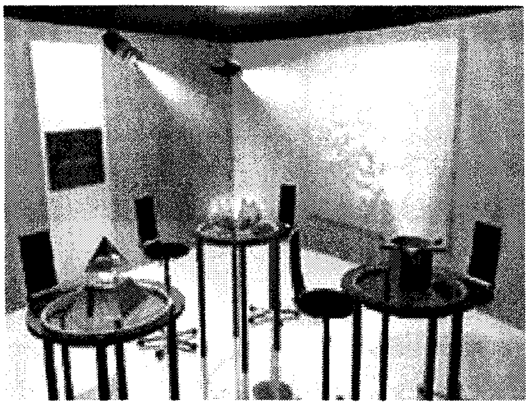

Figure 6 - Knowledge=Power CD-ROM

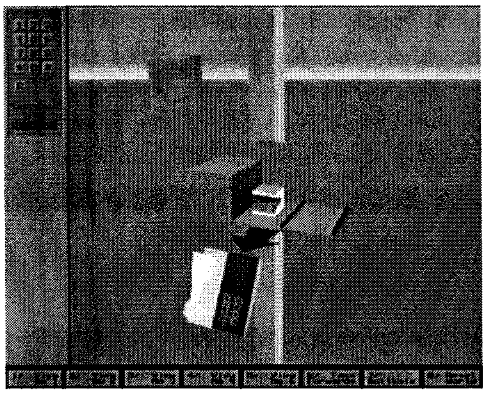

Figure 7 - Call Waiting Case Study

However, in the development of new visual representations, such as the three-dimensional interface, any assumptions appropriate to old media should be rigorously challenged before being accepted. In this way, questioning our selection of assumptions and revising them, where appropriate, can be seen as an important first step in the development of the media to suit its inherent qualities. The potential for a new medium to change and form society should not be underestimated and with HCI Design the important role the designers play in creating the 'rules' and framework should not be left to technological determinism alone. As Brenda Laurel cites: "Movies did not flourish until the engineers lost control to artists - or more precisely, to the communications craftsmen. The same thing is happening now with personal computers".[27]

We know a lot about iconic interfaces, as Peter Cochrane notes: "For over 15 years icons have become well established as a means of navigating computer environments. But they are flat, static, and only able to convey limited information."[28] How they work and what their benefits are has long been studied, yet beyond this there are other examples where designers have attempted to move away from real world referents for their virtual representations. In many instances this has been the result of Simulation, where scientists are attempting to model complex physical systems and simply have no real world objects to mimic. As Kevin Robbins highlights;

"New dimensions of reality are opened up to the powers of observation. With computer graphics stations, it becomes possible to 'see' things that are otherwise inaccessible to the human gaze...It is now actually possible to visualise the interior of a dying star or a nuclear explosion. The mind can go places where no physical being will ever be likely to go."[29]

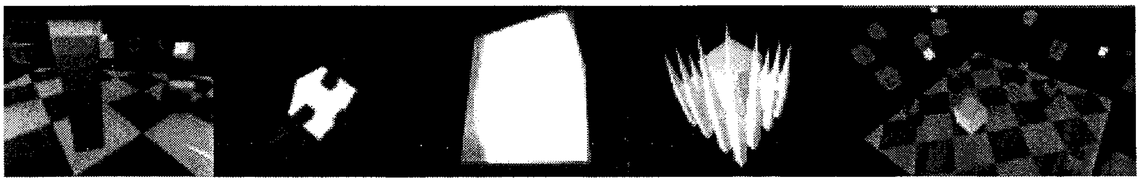

Figure 8 - Emotional Icons Case Study

These non-iconic interfaces model systems using Euclidean geometry and symbolic interface are widely thought to be opening up new areas of scientific observation. Such new knowledge is encouraged by moving beyond the Déjà vu of the real world iconic metaphor. As Michael Heim notes, "Virtual worlds evoke imagination only if they do not simply reproduce the existential features of reality but transform them beyond immediate recognition."[30] Several examples undertaken at BT Laboratories have involved using abstract forms with emotional characteristics (Figure 7 & 8). Such interfaces might be termed *symbolic metaphors* and have metaphoric associations on at least one level, yet are embodied in an arbitrary symbolic form. This is a mode of representation which designers currently seldom explore, either by technological determinism, convention or through so called 'user centred' approaches that dwell in charted territory. Peter Cochrane refers to such space opportunities as hyper-geographic;

"When we move to the world of the bit, we encounter a new geography of multiple dimensions. This world is a networked n-dimensional space of multiple copies, existence, connectivity, locations and forms. Our concepts of physical geography do not easily translate in this new hyper-geographic world."[31]

The research underlying this paper is currently developing a taxonomy to identify this segment of computer human interface. This is being achieved by overlaying the following key considerations: Modes of representation (i.e. symbol, index icon), Dimensionality (i.e. 2D, 3D, 4D and beyond), Modes of engagement (i.e. enactive, iconic, symbolic) and Interactivity (i.e. linear, user defined). The aim of this taxonomy is to indicate the nature of the differences *within* the three dimensional interface. Although it is a fundamental help to understand the nature of these differences, the question remains, how can we transcend conventional mimetic interfaces, such as the desktop metaphor where and when appropriate in interface design? Fiske notes this dilemma in our everyday communication experiences, such as greetings, where he proposes the idea of 'boundary rituals'. Fiske suggests that to cope with the changes that take place as we transcend boundaries, we involve ourselves in rituals. Therefore, typical examples might be the transition from presence to absence, as with greetings; however, the greater the change required, the more elaborate the ritual, so the transition from single life to married life, involves a 'wedding' party (this can also be seen with the 'launch' of new software). These occasions form a kind of blurring, where perhaps in Berlyne's description we are experiencing higher levels of stimulation which enable the changes in conceptual understanding of categories to take place. It might be metaphorically envisioned as a boat moving from lock to lock, requiring a rush of water to 'even out' the transition.

From this discussion of theories of communication, it is possible to draw some conclusions concerning the role of the image in HCI design. The paper has aimed to make alternative approaches to HCI design content explicit within a holistic, structured concept of the medium of communication. Although it seems clear that the development of modes of representation beyond the iconic require users to develop new knowledge and associations, such representations are aligned to much longer term, user-centred goals where the ultimate goal is new knowledge. This paper represents a starting point, a space where more research needs to be undertaken in order to make alternative methods of 'understanding' and deciphering interface explicit. A good place to start seems to follow Marshall M^c^Luhan's suggestion that, "Everybody experiences far more than he understands. Yet it is experience rather than understanding, that influences behaviour." Transcending the conventional mimetic interface is perhaps most easily achieved by bearing in mind the experiences users have of the world and the power of narrative in explaining them. Although some psychologists and philosophers[32] suggest that we are fundamentally metaphysical and need to use the real world as a reference, within the computer environment this does not eliminate more abstract iconography combined with clear user narratives. Image plays a significant role in the narrative process, but its power is not absolute. As we have seen, other types of media also have a role to play. Most importantly of all is the development of designer's understanding of the medium so they can produce the kind of representations that are appropriate in a given context. These conclusions have particular relevance for interface designers and information architects to assist their exploration of the characteristics of three-dimensional interfaces as a means of revealing new knowledge through visual communication systems.

[3,978 words]

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[2] Semiotics - The general (if tentative) science of sign, systems of signification, means by which human beings individually or in groups communicate or attempt to communicate by signal: gestures, advertisements, language itself, food, objects, clothes, music etc.

[3] Op.cit ROBBINS.K. (1996) p149

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APPENDIX 13: BRAINSTORM & ANALYSIS WRITE UP

Literature review analysis

USERS PSYCHOLOGY COMMUNICATION MEDIUM REPRESENTATION GENRES CASE STUDIES AFFORDANCES TYPES OF VR HARDWARE SOFTWARE US ACADEMCI UK ACADEMIC EVENTS

USERS

- suspension of disblief
- immersion
  - mental
  - physical
- authorship versus creatorship
- participants drive narrative
- situational awareness
- navigational awareness
- participatory design
- collaboration
- user monitoring
- world monitoring
- qualitative data
- quantitative data

PSYCHOLOGY

- pattern recogition
- object permanence
- mentally construct a continuous unified reality (closure)
- mental models:
  - divide and conquer
  - global network
  - progressive expansion
  - narrative elaboration
- mental model
- collaborative environment
- Back story
- "new technology hype cycle"

COMMUNICATION MEDIUM

- medium: something that is between two or more things
  - storage medium
  - carrier medium
- venue
- cartography
- feedback
  - sensory feedbac
  - feedback loop
- * scale
- * use of metaphor
- * coherence and consistency
- experience designers
- substance
  - world geography
  - objects
  - agents
  - user interface
- experience design
- avatar
- visual / aural
- sonification
- input
- abstract sounds
- tactile cues

REPRESENTATION

- signs & symbols
  - iconography
- abstraction triangle
- physical representations (p-reps)
- ganter
- conceptualised representations (c-reps)
- abstraction
- vensimilitude
- post geographic
- the ultimate interface
- natural invisible interface
- magical properties
- hypergeographic
- realism
- mimesis
- simulation of complexity (SOC)
- physics:
  - static world
  - cartoon world
  - newtonian
  - aristotelian
  - choreographed
  - other world
- envisioning
- virtuality
  - nelson
- simulation of reality (SOR)
- -ve metaphor eroneous mapping of concept onto the instantiated interface

GENRES

- visualisation
- location walkabout
- manufacturing procedure analysis
- games
- interactive story
  - the mirror
  - osmose
- historical site recreations
- prototyping
- architectural walkthrough
  - architectural simulation
- form & genre

CASE STUDIES

- sculptural metamorphosis
- knowledge = power
- emotional icons
- call waiting
- concept 2010
- 3D retail
- Calvin

AFFORDANCES

- navigation
- landmarks
- markers
- a world in minature
- 1. travel 2. wayfinding
- point to fly
- virtual markers or crumbs
- action at a distance
- dplex decomposition
- lighting
- fidelity
- narrative
  - directed
  - flexible
- stories
- interactive or task
- denoument
- kinesthetic cues
- suboptimal interfaces
- interactivity
- manipulation
- communication

TYPES OF VR

- Artificial reality
- Augmented reality
- CAVE
- Hand held VR
- Head based VR
- Fish tank VR
- Cyberspace
- ubiquitous VR

HARDWARE

- Interface
- 6- DOF
- transducer
- props

SOFTWARE

- Division's Dvise
- virtuality group
- RENDERING
- computer graphics
- field of view
- origin
- level of detail culling
- polygons, nurbs and csg
- raytracing
- resolution quality
- animated texture maps
- image based rendering

US ACADEMCI

- Electronic visualistation lab EVL
- georgia insitute of technology
- NASA
- HIT Lab university of washington
- university of v virginia
- university of houston & george mason university
- BOOKS
- virtual light
- neuromancer
- snowcrash
- wireframe

UK ACADEMIC

- Salford VR centre
- Teeside VR centre
- UCL
- UK COMPANIES
- Radical Multimediat group at BT
- IBM
- Media Lab Europe

EVENTS

- VRCAI
- ACM Symposium
- CHI 04 vienna
- IEEE VR
- IEE

LITERATURE REVIEW AND EXPERT EVENT FINDINGS

LITERATURE REVIEW | MULTIVIEWPOINT | SEMIOTICS IN HCI | VISUALISING THE FUTURE

Representation

- Iconography and modes of representation icon/index/symbol
- sound
- animation
- realism versus abstraction
- metaphor
- The role of context and venue
- coherence and consistency
- convention
- modes of engagement enactive/ iconic/symbolic
- VR as a language

Interaction

- User centred interaction
- mental models
- direct manipulation and feedback

Usability

- narrative
- authorship versus creatorship
- interaction, linear versus non linear

Design

- Missing design process
- participatory design
- collaboration
- presence

Technical

MULTIVIEWPOINT

- Real time testing
- documentation tool for design stages
- marketing and sales modify colours etc
- visualise difficult to access data
- perform design changes quicker and cheaper
- objects with affordances
- beyond the physical view it from a disctance
- jump to other worlds
- multiple views on data
- live modelled world

SEMIOTICS IN HCI / VISUALISING THE FUTURE

- Relationship between epistemology and systems of representation
- referential transparency
- relationship of 3D and 4D travelling in time
- relationship between reality and virtual
- role of 3D media in culture realism and symbolism

- consequences of actions
- 3D brand
- Self generated narrative
- interaction what is the new part?
- consequences of virtual actions
- Implications of western metaphors of space
- where does the media stop

- ethics
- relation to land as a commodity how to divide?

- relationships between things
- collaborative work
- multiple viewpoints
- 3D brand
- non linear info
- the utopian view is necessary to develop practice
- what are the ways into the medium
- utopian and market visions
- what are the affordances?

PHASE ONE CASE STUDIES FINDINGS

SCULPTURAL METAMOPHOSIS

- role of convention
- +ve communicated a richer set of information
- +ve relationship of information to be visualised
- +ve conveying ideas more intuitively using real world experience
- +ve demonstration of interrelated complex and non linear information
- -ve abstract form difficult to read

KNOWLEDGE = POWER

- role of mimesis
- difficulty of transcending media types
- use of animation to draw user's attention
- real world objects constraining interface due to metaphor
- metaphor should have a logic to its real world counterpart
- metaphor should apply across the board

EMTIONAL ICONS

- complicated or volumous information
- illustrate complexity or complex information
- changes in form (scale)
- change in form is significant to understanding
- revealing relationships
- revealing structure
- intuitive to a range of people
- immediacy of the information
- information which needs to be assimilated quickly

PHASE TWO CASE STUDY FINDINGS

MODEL

- role of the designer as audience

CALL WAITING

- effect of software on design
- role of mental models
- role of navigation
- limitations of realism
- cross cultural issues
- consistent use of icons
- +ve interactive
- 3D sound
- +ve the importance of 3D sound
- +ve design control by the creator rather than the programmer
- +ve ability to make changes easilty and iterativelly
- +ve it got used totally out of proportion to the time it took to create
- +ve more flexible to solve problems
- +ve control of the visualisation by the designer
- +ve abiltiy to set and readjust viewpoint
- +ve control over viewpoint/abilty to change viewpoints
- +ve smaller file than equivalent animation
- +ve the ability to animate a mental model
- +ve Self selling potential
- +ve ability to communicate to different users
- +ve speed at which you could generate animation
- -ve poorly designed inconsistent tools
- concern over heavy reliance on clip objects
- How to represent a call?

CONCEPT 2010

- use of space to denote importance
- relativity of objects i.e. role of scale
- role of landmarks
- +ve importance of sound (but could disturb in open plan)
- +ve easy to use interface
- +ve intuitive
- +ve fun
- +ve ability to spatially arrange data rather than overlapping 2D
- -ve visual summary of complex information and relationships
- -ve dificulty in representing concepts with no real world counterpart
- -ve softwares ability to render surfaces (later resolved)
- 2D should always remain 2D, don't perspectivise

3D RETAIL

- role of virtual brand consistency
- +ve users control
- +ve child's viewpoint of a room, disabled access
- +ve interactive
- +ve invisibility of the interface and technology
- +ve ease of use
- +ve intuitive
- +ve fun
- +ve ability to juxtaposition things in space
- +ve users perception of impact of scale
- +ve ability to utilise different viewpoints
- -ve 2D was better for speed and familiarity to users